Ada and Software
Management in NASA:
Symposium/Forum

June 1989

NASA

National Aeronautics and
Space Administration

Goddard Space Flight Center
Greenbelt, Maryland 20771

Ada AND SOFTWARE MANAGEMENT IN NASA: SYMPOSIUM/FORUM

Organized by
the Ada and Software Management
Assessment Working Group

May 31 and June 1, 1989

GODDARD SPACE FLIGHT CENTER
Greenbelt, Maryland

INTRODUCTION

In June 1988, the National Aeronautics and Space Administration (NASA) Information Resources Management (IRM) Council established the Ada and Software Management Assessment Working Group (ASMAWG). The IRM Council directed the ASMAWG to assess the NASA posture on software management and Ada technology, define means to build NASA's base of knowledge and experience in Ada and software engineering, and develop a plan for carrying NASA toward state-of-the-art software technology. The ASMAWG consisted of seven members and four advisors. It was chaired by Frank McGarry of Goddard Space Flight Center (GSFC). The ASMAWG produced two reports: *Ada and Software Management in NASA: Assessment and Recommendations* (March 1989) and *NASA—Evolving to Ada: Five-Year Plan* (April 1989).

When McGarry presented his final briefing to the IRM Council in April 1989, the Council requested that he organize a symposium and forum to

"a. Debrief all interested agency staff as to the basis for the findings and the Group's rationale supporting the resulting recommendations;

b. Provide an open forum to explore the many facets of the material covered by the Group; and

c. Provide any other material which agency staff might need in order to prepare comments on the Group's proposal."

The symposium and forum were held at Goddard Space Flight Center in Greenbelt, Maryland, on May 31 and June 1, 1989. The symposium (first day) was devoted to McGarry's summary of the ASMAWG's findings and recommendations and to responses by major NASA software contractors. The forum (second day) consisted of a series of panel discussions primarily involving representatives of NASA centers and headquarters.

Noel Hinners, then chairman of the IRM Council, requested that by July 1989, attendees of the symposium and forum should submit comments on the ASMAWG's reports to their IRM Council representative. The Council member will forward the comments to Wallace Keene, Executive Secretary of the IRM Council. Keene will consolidate the comments and formulate a collective response and recommended action plan, which he will submit to the IRM Council. Hinners expressed his hope that the IRM Council would adopt an action plan that responds to the reports by September 1989.

1

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NASA

National Aeronautics and
Space Administration

Washington, D.C. ÷
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JUN 27 1988

Office of the Administrator

TO: NASA Information Resources Management (IRM) Council

FROM: ADI/Chairman, NASA IRM Council

SUBJECT: NASA IRM Council; Ada and Software Management
Assessment Working Group

At the March 1988 meeting, the NASA IRM Council was advised that
the Space Station Program has committed to use the Ada language
for its flight systems and that the agency has a number of other
ongoing Ada project and evaluation efforts. Concern was
expressed that the agency may not have the necessary
infrastructure to support using Ada. The Council was unaware of
any comprehensive software management program or comparable Ada
strategy to assure such an infrastructure is in place as needed
by the agency. It was also observed that the agency has no
coordinated strategy to leverage current Ada experiences for
potential application on future projects.

The Council recommended an appropriate group be appointed to
assess the agency's ongoing and planned Ada activities and the
infrastructure supporting software management and the Ada
activities (present and projected). As a result, I am
establishing the Ada and Software Management Assessment Working
Group made up of the following chairperson and members who have
agreed to participate in this effort.

Chairperson:

Francis E. McGarry, Head, Systems Development Branch, Goddard
Space Flight Center, Code 552

Members:

Donald W. Sova, Deputy Manager, Software Management Assurance
Program, NASA Headquarters, Code QR

John W. Wolfsberger, Systems Software Branch, Marshall Space
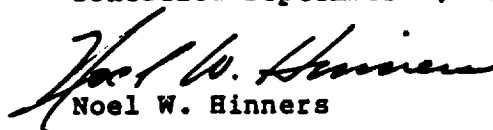Flight Center, Code EB42

Robert A. Carlson, Manager, Software Services Contract, Ames
Research Center, Code RCA

Edward S. Chevers, Assistant Chief, Avionics Systems Division,
Johnson Space Center, Code EH

5443

Arthur I. Zygielbaum, Deputy Manager, Information Systems
Division, Jet Propulsion Laboratory, Code 360

John L. Feagon, Chief, Software Engineering Office, Lewis
Research Center, Code 4010

The group should review the agency's software management programs
and present an Ada implementation and use strategy appropriate
for NASA over the next 5 years. I would like the group to
present a report on its progress, including a schedule for
completing the assessment, at the next NASA IRM Council meeting
scheduled September 8, 1988.

Noel W. Hinners

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LeRC/4010/J. Feagon
MSFC/DA01/J. Thompson
MSFC/EB42/J. Wolfsberger
SSC/AA00/J. Hlass

5443

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National Aeronautics and
Space Administration

Washington. D.C.
20546

Office of the Administrator

TO: Officials-In-Charge of Headquarters Offices
            Directors, NASA Field Installations
            Director, Jet Propulsion Laboratory

FROM: ADA/Associate Deputy Administrator

SUBJECT: Ada and Software Management Assessment Symposium

In March 1988, the NASA Information Resources Management
(IRM) Council chartered the Ada and Software Management
Assessment Group (hereafter called the Group) under the
leadership of Mr. Frank McGarry, Goddard Space Flight Center.
The Group's objectives were to assess the state of software
management within the agency and the adequacy of the agency's
infrastructure supporting the Ada programming language and to
recommend improvements in both areas, where indicated. The
Group concluded its assessment this past March and reported
its findings and recommendations to the Council on April 10,
1989.

The Group found, in general, that ample opportunities exist
for effectively coping with the risks inherent in the
changing environment of software technology, but that no
organization was chartered to coordinate such efforts. As a
consequence, the agency bears increased risks of duplicating
effort with minimum potential for leveraging our software-
related investments. The Group observed that the agency's
software costs have been increasing exponentially and placed
the current software-related expenditures at approximately
20 percent of the agency's budget. The Group further found
that the agency may be unprepared to manage its current and
planned Ada-based software development projects. The Group's
findings are documented in the enclosed report entitled:
"Ada and Software Management in NASA: Assessment and
Recommendations." The Group's proposal for addressing their
concerns is provided in the enclosed report, entitled:
"NASA-Evolving to Ada: Five-Year Plan."

It is apparent to the Council that NASA is on course which
will lead, in due time, to the adoption of Ada for new
mission software. This is not to say there won't be
exceptions; however, given the direction of software
management methodologies, the maturation of Ada-related

4

technologies, and a swelling Ada constituency (both in the public and private sectors) it is just a matter of time before the majority of the agency's programs and projects select Ada. The question, therefore, seems to be how best should the agency manage the evolution to Ada so that it will reap the maximum benefits. In this regard, it is absolutely necessary that NASA fully understand the attendant implications, risks, and challenges.

To begin an agency dialogue on this subject, which I expect will lead to a comprehensive set of action plans, I have asked Mr. McGarry and the Group to conduct an Ada and Software Management Assessment Symposium. The purpose of the Symposium will be to:

    a. Debrief all interested agency staff as to the basis for the findings and the Group's rationale supporting the resulting recommendations;

    b. Provide an open forum to explore the many facets of the material covered by the Group; and

    c. Provide any other material which agency staff might need in order to prepare comments on the Group's proposal.

Mr. McGarry has scheduled the Symposium for May 31 and June 1, 1989, at the Goddard Space Flight Center in Greenbelt, Maryland. Your attendee(s) (both government and contractor personnel) should contact Mr. McGarry directly at:

    Mr. Frank McGarry
    NASA Goddard Space Flight Center (Code 552)
    Greenbelt, MD   20771
    (FTS) 888-6846 or (301) 286-6846.

Mr. McGarry's staff will work directly with your attendee(s) regarding the agenda and associated logistics.

Following the Symposium, I would like your endorsement, comments, concerns, and recommendations regarding the Final Report and the Five-Year Plan. I would like your comments submitted in writing to the Council's Executive Secretary, as indicated below, by July 7, 1989:

    Mr. Wallace Keene
    Executive Secretary, NASA IRM Council
    NASA Headquarters (Code NT)
    Washington, DC   20546

5443

Your comments will then be synthesized into a specific plan
of action for review and endorsement by the IRM Council and
implementation by the Agency.

I cannot over emphasize the importance of this Symposium and
your comments in structuring a proper and measured agencywide
response to this problem. We need your support, and I look
to you to help ensure appropriate representation at the
briefing. Additional copies of the final report and Five-
Year Plan are available from Mr. McGarry. I remind you that
both documents are the product of the Ada and Software
Management Assessment Working Group and do not necessarily
reflect NASA's official position. Please have your
representatives contact Frank as soon as possible to schedule
their attendance.

Noel W. Hinners

2 Enclosures

5443

FINAL AGENDA

Ada AND SOFTWARE MANAGEMENT IN NASA
SYMPOSIUM/FORUM

MAY 31 AND JUNE 1, 1989

NASA/GSFC
BUILDING 3 AUDITORIUM

Wednesday, May 31, 1989

7:30 – 8:30	Registration		
8:30 – 10:30	(Session 1)	Findings and Recommendations of the 'Ada and Software Management Assessment Working Group'	Frank McGarry, NASA/GSFC, Chair–ASMAWG
10:30 – 11:00	Break		
11:00 – 12:00	(Session 2)	Industry Perspective of Recommendations	

        11:00 Review 1 Ray Wolverton and Bruce Krell/Hughes
        11:30 Review 2 Judy Fleming/IBM

12:00 – 1:30	LUNCH	
1:30 – 3:00	(Session 3)	Industry Perspective of Recommendations

        1:30 Review 3 Dick Taylor/CSC
        2:00 Review 4 Joe McCabe/McDonnell Douglas
        2:30 Review 5 Mike Hollowich/TRW

3:00 – 3:30	Break	
3:30 – 5:00	(Session 4)	Industry Perspective of Recommendations

        3:30 Review 6 Jeff Neufeld/GE
        4:00 Review 7 Kent Lennington/Lockheed
        4:30 Review 8 Weldon Jackson/Boeing

5:00	ADJOURN – Day 1

7

Ada AND SOFTWARE MANAGEMENT IN NASA
SYMPOSIUM/FORUM
(CONTINUED)

Thursday, June 1, 1989

7:30 – 8:30	Refreshments	
8:30 – 10:15	(Session 5)	PANEL/FORUM Potential Effects on NASA (Facilitator – Frank McGarry)
	Panelists:	Jack Garman (JSC) Sue McMahon (HQ/OSSA) Tom Thornton (JPL) Rob Kudlinski (LaRC)
10:15 – 10:45	Break	
10:45 – 12:15	(Session 6)	PANEL/FORUM Potential Effects on NASA (Facilitator – Ed Seidewitz/GSFC)
	Panelists:	John Dalton (GSFC) Debbie Hahn (KSC) Al Kopp (Telesoft, formerly DoD) Tony Carro (HQ/OSO)
12:15 – 1:30	LUNCH	
1:30 – 3:00	(Session 7)	PANEL/FORUM Potential Effects on NASA (Facilitator – Vic Basili/Univ. of MD)
	Panelists:	Paul Smith (HQ/OAST) Dave Aichele (MSFC) Kathy Schubert (LeRC)
3:00 – 4:00	Plenary Session – Summary (Facilitator – Frank McGarry)	
	Panelists:	Jack Garman (JSC) John Dalton (GSFC) Paul Smith (HQ/OAST)
4:00	ADJOURN – Day 2	

5443
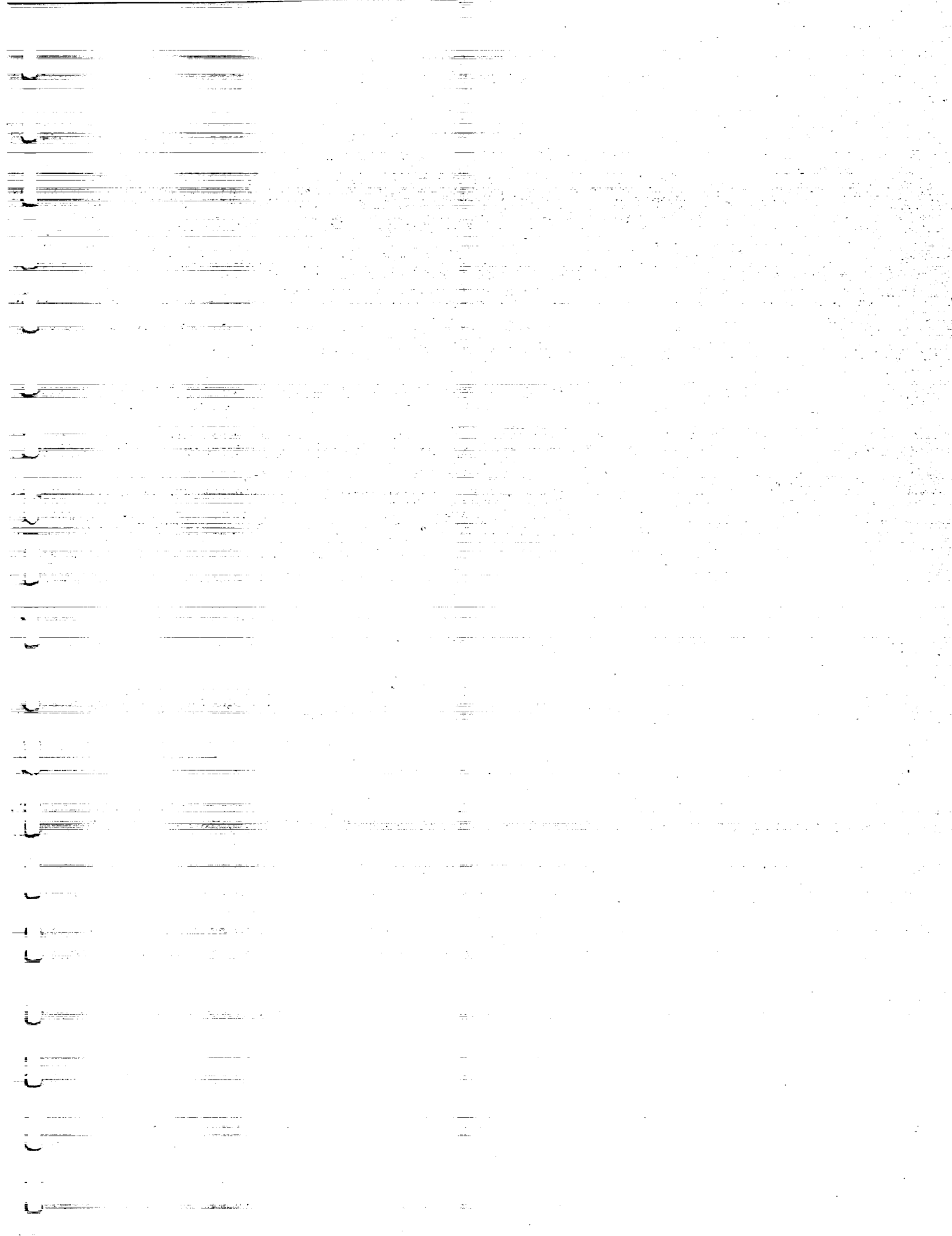
Ada AND SOFTWARE MANAGEMENT IN NASA SYMPOSIUM

SESSION 1: ASMAWG FINDINGS AND RECOMMENDATIONS

Frank McGarry

Frank McGarry of GSFC, chair of the ASMAWG, opened the symposium on the first day by presenting a summary of the working group's findings and recommendations.

McGarry stated that the IRM Council commissioned the ASMAWG's study to investigate (1) the promises of Ada to improve software productivity and quality and (2) claims that a transition to Ada would require significant changes in NASA's training programs and ways of doing business. In appointing the working group, IRM Council chair Noel Hinners said that the study should "assess the agency's ongoing and planned Ada activities and the infrastructure supporting software management and the Ada activities (present and projected)" and that it "should present an Ada implementation and use strategy appropriate for NASA over the next 5 years."

McGarry noted that historically NASA has produced high-quality software, but that the amount and complexity of NASA's software have been increasing greatly and that software engineering technology has been advancing rapidly. The increasing complexity of NASA's missions, the expanded functionality of its software, and the huge amounts of data that this software must process suggest that some changes in the agency's approach to software may be necessary. Although a number of individual projects, most notably the Space Station Freedom Program (SSFP), have selected Ada, NASA has no agency-level policy about the use of Ada or the training, research, or new infrastructure that the use of Ada may require.

McGarry then presented the ASMAWG's findings and recommendations. The key finding is that Ada is an appropriate vehicle to support the evolution to improved software practices in NASA. The ASMAWG also found that the agency's current training programs, Ada experience base, agency-level planning, software standards, internal support organizations, software research, and measurement programs are inadequate to support a transition to Ada and to the use of the best software engineering practices.

The ASMAWG's key recommendation is that NASA should adopt Ada as its standard programming language for all mission software and should phase in its use over a 10-year period. Management of the transition to Ada and to improved software engineering should be the responsibility of two new task forces: the Software Engineering and Ada Implementation Task Force (SEAITF) and the Software Process Engineering Task Force (SPETF). The agency should also develop agency-wide standards for software management, development, acquisition, and assurance. NASA should also formulate a set of functional capabilities for a standard

5443

software development environment and generate these capabilities on common support systems. NASA should establish incentive programs to make Ada and state-of-the-art software engineering attractive to its contractors. Finally, NASA should expand its efforts in Ada and software engineering training, research, and measurement.

In closing, McGarry stated that the working group was not prepared to place a total dollar figure on the plan but thought that NASA would have an easier time identifying required funding than identifying required NASA personnel. He stated that adoption of the plan would not decrease NASA's overall software budget but would result in an increase in the functionality and reliability of NASA's software and a decrease in cost for given functionality. He considered the plan to be an integrated whole and was not willing to prioritize the recommendations or indicate which ones he would be willing to forego in favor of others.

In response to questions from the attendees, McGarry stated that he presumed that funds for training and other agency-wide transition costs would be provided by NASA institutional sources rather than from the budgets of individual projects. He thought that it might be possible to estimate the costs of carrying out some of the particular recommendations, such as that pertaining to standards development, but it would take the next detailed level of planning before a more precise cost could be determined for the entire set of recommendations.

Some attendees were concerned about whether enough Ada programmers are being trained by the universities. McGarry and Marvin Zelkowitz of the University of Maryland stated that they thought general training in computer science and software engineering was more important than language training at the university level and that NASA could provide Ada training for graduates with such backgrounds. However, McGarry felt that the precise definition of a training program and the determination of the numbers of persons who should participate in it are beyond the scope of the ASMAWG's activities.

McGarry stated that he would like to see headquarters establish a permanent office in charge of the agency's software engineering. The recommended task forces that primarily consist of center personnel working part-time or temporarily should be seen as stopgap measures.

McGarry called on Daniel Roy, chair of the Performance Issues Working Group of the Special Interest Group on Ada, to answer a question about the efficiency of object code generated by today's Ada compilers. Roy responded that the speed of such code is adequate for most applications, excluding those that must run on certain microprocessors. He stated that the best optimizing Ada compilers are as good in this respect as the best C compilers. He also said that Ada's concept of the program library makes possible an entirely new class of optimizations that are not possible, for example, with FORTRAN.

10

INDUSTRY PERSPECTIVE ON RECOMMENDATIONS

SESSION 2

McGarry then proceeded to introduce a series of industry representatives. He had asked each company to review the ASMAWG's recommendations and assess their impact from the company's perspective.

Hughes Aircraft

Ray Wolverton, Chief Scientist at Hughes Aircraft, introduced the Hughes response. Bruce Krell, Senior Scientist/Engineer, presented the body of the briefing.

Hughes strongly supports the entire plan, because it recognizes growing contractor capabilities and mirrors similar activities in Hughes. Hughes has already used Ada on projects with stringent requirements, and feels that the 1998 target date for completing the transition to Ada is conservative.

Krell proceeded to address each recommendation individually. Hughes agrees that NASA should evolve to Ada as its standard programming language. Like most major NASA contractors, Hughes is making major investments in software technology for Ada and is building an extensive Ada experience base. It is important to have a waiver process, however. There is a large legacy of code written in other languages, and some things cannot be done well in Ada. Waiver approval authority must be at an appropriate level.

Hughes supports the establishment of a Software Engineering and Ada Implementation Task Force (SEAITF). A major change requires a sponsor within the organization.

They agree that NASA should develop and adopt tailorable standards for software development, management, and assurance. Standards facilitate communication between contractors and NASA, and they enhance the repeatability and predictability of the software development process. However, they should be tailorable by deletion or addition.

Hughes agrees with the concept of functional commonality for NASA software support environments. However, NASA should recognize that tools are evolving rapidly and that the marketplace should be left free to adopt the best tools available at a given time. In addition, NASA will benefit if contractors use their own existing resources.

Krell said that Hughes agrees that each center should develop a plan for evolving to Ada. Because effective software engineering and Ada must reflect specific missions and applications, the plans should reflect the needs of the individual centers and their missions. Hughes has taken this approach internally for different product lines.

11

They agree with the development of a core curriculum in software engineering and Ada. Krell then elaborated on the content and length of the courses in Hughes' core Ada curriculum.

They agree with the requirement to write and implement a risk management plan for critical projects. A risk management plan for Ada projects can help reduce the perceived risks of evolving to Ada. They added, via Bryce Bardin, that risk management plans should be generated for *all* projects, not just critical ones.

Hughes feels that incentives from NASA to use Ada are not necessary for large system houses. Incentives could, however, be useful to encourage software reuse and to assist smaller companies that are not yet committed to Ada.

They agree with the recommendation for agency-wide coordination of software research and development (R&D) because such coordination will improve the infusion of Ada technology and accelerate the transition to Ada.

Hughes supports the establishment of an agency-wide program to collect and use software metrics because metrics are necessary to manage the software development process. A phased approach to metric collection should be used, starting with a small number of key statistics.

They support the establishment of a Software Process Engineering Task Force as a natural conclusion from previous comments.

In response to questions, Krell stated that it is not possible to separate the costs or benefits of software engineering from Ada: the two must be used together. He also said that those who have been exposed to Ada and software engineering tend to use them on other projects, not just on mission software. Finally, he said that Hughes has had to provide Ada training rather than rely on colleges, which tend to ignore data abstraction and tasking.

IBM

Judy K. Fleming, Manager of Space Station Software Engineering at IBM in Houston, presented IBM's response. She said that the ASMAWG reports are similar to some IBM internal reports. IBM has experienced growing pains and formulated plans to alleviate them in a similar fashion. For NASA to adopt Ada would be a "great idea." Both IBM and NASA recognize the need to adopt new software engineering technologies and tools as much as a new language.

Fleming asked whether the NASA role is to acquire software or perform Ada development. These roles require different foci in training, standards, and development environments. In either case, she thought that NASA should build on the considerable work already done by contractors, academia, and the DoD.

She said that the selection of Ada for the Space Station Freedom Program (SSFP) represents an enormous commitment by NASA. The SSFP provides an

opportunity to accelerate the milestones in the ASMAWG 5-year plan and to fulfill larger agency objectives. The SSFP's Software Support Environment (SSE) provides leverage as a prototype development environment. NASA should use it, learn from it, and focus reuse and measurement activities on it.

Fleming then made the following specific comments on the recommendations:

Ada Adoption. NASA should establish a clear strategy for the use of pre-existing non-Ada code and commercial off-the-shelf software. NASA should identify a few acceptable special-purpose languages such as fourth-generation languages for database interfaces and nonprocedural languages for artificial intelligence and expert systems. NASA should use R&D efforts to facilitate the coexistence of special languages with Ada.

SEAITF. This is a good mechanism to spread lessons learned throughout NASA. The SEAITF could serve as NASA's pipeline to DoD, the Software Engineering Institute (SEI), Software Technology for Adaptable and Reliable Systems, and similar organizations. IBM would like to participate in the SEAITF.

Policies and Standards. IBM agrees with the idea of tailorable standards and recommends an agency-wide focus on review points (especially "red flags"), measurements, reuse, and deliverables and their formats. The SSFP is developing its own standards and procedures, which could evolve into standards for agency-wide use.

Software Development Environment. NASA is already developing a prototype environment, the SSE, and is too far along to invest in another prototype. NASA should learn from the SSE and influence its evolution, especially with respect to metrics, reuse, and the integration of software deliverables. IBM supports the specification of functional capabilities but not the development of specific tools on specific platforms. IBM recommends defining a framework of interface specifications that promote maintainability, portability, and reusability but do not limit contractors' use of the latest and greatest tools and methods.

Training. The recommendation is a reasonable approach. Project-specific training will also be needed, and access to a cadre of experts following training would enhance on-the-job training.

Risk Management. A risk management plan is required for SSFP. Ada-specific content should be added.

Contractor Incentives. Ada readiness is an essential consideration in the proposal evaluation process. It is probably unnecessary at this late date for NASA to share training costs. Incentives should focus on reuse, making it financially rewarding to reuse rather than build. NASA should also recognize the life-cycle shifts implicit in the use of Ada, proper software engineering practices, reuse, and prototyping.

Software Measurement Program. NASA should drive the SSE to meet agency-wide requirements. The SSE developers already have plans for tool support of the

13

collection of a wide range of software metrics. The Jet Propulsion Laboratory's software cost engineering specialists should also be involved. They have historical data and a proven methodology for data collection and analysis. Finally, NASA should take advantage of the SEI Measurement Task Force.

In response to questions, Fleming said that IBM's transition to Ada was not difficult. They were able to modify their existing software engineering courses to apply to Ada. Nor did IBM suffer severe internal resistance to Ada once real Ada activity began (in the last 3 to 5 years). The economic effects of front-end loading the development cycle will not be apparent until IBM has recorded cost data for long periods.

SESSION 3

Computer Sciences Corporation (CSC)

Dick Taylor, Assistant to the President of the System Sciences Division, presented CSC's response. CSC's overall impression is that the report is thoughtful, candid, accurate, well done, and a rational basis for beginning. CSC feels that software engineering is central to building current and future systems. Future successes are increasingly dependent on greater discipline, quality, and productivity. Production of new software engineers fails to meet demand. A long-term view is mandatory to achieve significant change. The keys to greater quality and productivity are a commitment to software engineering principles, standardization without excessive constraint, trained and motivated people, measurement, R&D, and software reuse.

Taylor made the following specific comments on the recommendations:

Ada Adoption. CSC supports NASA's adoption of Ada as a standard programming language. They agree with the ASMAWG's focus on standardization and think that Ada supports software engineering, fosters personnel growth and retention, and promotes reuse. CSC thinks that standardization must be supported with training; that the transition requires a long-term view; and that risks, resource needs, and schedule impacts must be explicitly treated in acquisitions.

Training. CSC supports the recognition of both the importance of training and the scope of training needed. CSC also supports the formulation of a NASA curriculum and NASA-wide training. CSC is concerned, though, that NASA may not fully recognize the costs involved, the effect of the competitive procurement environment, and the role of the NASA curriculum for contractors.

Research and Development. CSC agrees with the recommendations for NASA-wide coordination of R&D, enhancement to greater Ada scope, environment and tool definition, metrics definition and use, resolution of Ada problems, and pilot projects. However, CSC thinks that tool and process R&D should focus on requirements specification issues and should strive for synergism with other R&D programs.

14

NASA Infrastructure. CSC supports the development of common NASA standards, agency-level organizations for focus and coordination, and the functional definition of an environment. CSC would not like to see NASA adopt overly rigid standards, substitute task forces for real infrastructure, or standardize on an overly specific environment. Nationwide standards are needed that are common to NASA, DoD, and FAA.

Reuse. CSC agrees that reuse is the key to increased productivity and that it is currently in a rudimentary state.

Metrics. CSC agrees that metrics are essential to process improvement and that NASA should define agency-wide standard metrics, starting with the essential ones. CSC is concerned with the relation of the recommended NASA program to other metric programs; the need for confidentiality of the measures; and the objective measurement of quality, reliability, adaptability, and flexibility.

Contractor Incentives. CSC agrees that acquisitions should encourage improved software engineering. CSC is concerned about ambiguities in requests for proposals, the evaluation of training costs, and productivity expectations during the transition to Ada. The contractors' key incentive is to win contracts, and NASA must be clear about the criteria for winning.

Taylor summarized by saying that the report is a fine baseline for departure and identified many key issues. Joint NASA and contractor action is required. The program needs to be formalized. Many of the issues involved are broader than NASA: DoD, SEI, and the Software Productivity Consortium have addressed many of them already.

McDonnell Douglas Space Systems Company and McDonnell Douglas Electronics Systems Company

Joseph J. McCabe, Manager of Software Integration and Testing at the Space Station Division of McDonnell Douglas Space Systems Company, presented McDonnell Douglas' response. He stated that the recommendations are basically good and that the 5-year plan supports the recommendations. However, the ASMAWG's approach may not be the most cost-effective. It requires long-term commitment and funding, NASA-wide support, and industry involvement. NASA needs to consider becoming more of an acquisition agency and less of a development agency.

McCabe raised several issues about the report:

- NASA should leverage resources outside the agency to achieve the report's goals.

- A new software support environment will only work if it is flexible, responsive to change, and fully supported.

15

- Training must extend beyond NASA and software groups to include systems engineering, product assurance, contracts, and finance groups.

- Metrics should be collected at large and should not be used as a weapon against contractors.

- Exceptions to the use of Ada should not require a complex waiver process, but justifications should be recorded in a knowledge base.

The plan would have a number of impacts on McDonnell Douglas. NASA standards and policies that differ from those of the DoD would create added expense. NASA should instead work with DoD-STD-2167 or its revisions. Creating and supporting a software support environment that conforms to a NASA standard could add cost and reduce efficiency. Selection of Ada will lower productivity during the learning curve. A complex metrics collection task and a risk management plan that is disproportionate to the project will add cost.

In summary, McCabe said that in general, McDonnell Douglas supports the recommendations and 5-year plan. Everybody would benefit from a focused effort. An integrated NASA/DoD/industry/academia plan is needed, and the task must be funded with a commitment from NASA to enforce the results.

TRW · ·

Michael Hollowich, System Engineering Manager for EOSDIS, presented TRW's response on behalf of Hal Hart, who had prepared the briefing but was unable to attend. He commended the working group for the work they had done and for their commitment to the insertion of Ada. He said that the next step should be a cost-benefit analysis to prioritize the recommendations. NASA has a major opportunity to profit from, if not join, the ongoing DoD initiatives in research, reuse, metrics, process models, standards, program office preparation, product and contractor assessment, and policy. The resulting commonality would benefit NASA's contractors as well.

TRW has questions about the recommendation for a common support environment:

- Does it imply a single, specific technical method for each life-cycle activity? Does it imply NASA acquisition of tools implementing a chosen set of technical methods?

- Does it require contractors to use a specific government-furnished toolset, or may a contractor's tools be substituted for government-furnished tools?

- Does the recommended "standard requirements for deliverables" mean representations of all artifacts of the development processes and their

16

interrelationships (that is, requirements traced to design, code, tests, and so on)?

- Does it imply portability of tools, either individually or as interacting suites? Does it recognize the tradeoffs and complex interactions among the following?

  - Support for reuse

  - Compatibility of technical methods (and data exchange between tools) chosen for different life-cycle activities

  - Compatible, exchangeable representations of information between environments

  - Adaptability to different projects' process models

  - Assistance to tool builders versus system builders

  - Commercial supportability of the support environment

SESSION 4

General Electric Aerospace

Jeffrey Neufeld, Manager of Advanced Programs, presented General Electric's (GE's) response, which focused on key NASA objectives that most strongly affect contractors.

Mandating Ada. GE endorses this recommendation for three reasons: standardization of languages alone is sufficient rationale; the market drivers for Ada are good business reasons to focus on Ada; and the software engineering advantages of Ada warrant confidence. GE thinks, however, that the waiver process should not be too burdensome.

Standards. GE endorses this recommendation because the adoption of standards focuses industry investments. GE strongly supports placing authority for tailoring standards at the NASA project manager level. GE is concerned that the report talks of developing NASA standards when DoD-STD-2167A is already established and supported by commercial tools. GE is also concerned that tailoring before contract award can complicate competitive price comparison and suggests having contractors bid to a project-modified baseline.

Software Development Environments. GE endorses the adoption of a standard for NASA in-house work and a functionally common environment for the contractor community to facilitate the interoperability of software products on large programs and to assess contractor readiness. GE does not think that NASA should develop an environment, because the commercial market is developing several. GE thinks

17

that specific tools, methods, and processes employed by contractors are significant elements in competitive postures. GE suggests that NASA simply define (1) standard formats to allow interoperability of software products and (2) functional capabilities of environments.

Contractor Incentives. GE endorses the recommendation. The report correctly focuses on the cost barriers of Ada and acknowledges the cost and performance risks of new technology. GE strongly concurs that financial incentives for contractor adoption of Ada and new software engineering will speed the payback to NASA. Consideration of a contractor's Ada and software engineering experience during acquisition will be a positive catalyst for change. GE has concerns on outstanding issues on incentives for reuse. Liability and warranty exposure, obligations and cost for testing, and data rights are issues that need to be resolved.

Three-Phase Transition. GE strongly concurs with a phased, integrated plan for the transition to Ada and improved software engineering. However, GE is concerned that the 10-year timetable will lag the industry and delay payback. GE suggests using Ada sooner on less complex and critical production projects.

Software Measurement Program. GE strongly concurs with a NASA standard metrics program and with the use of the SEI assessment method. GE is concerned that metrics do have cost, which may become a barrier in competitive situations, and that the SEI assessment method is not mature yet.

Neufeld concluded his remarks by saying that NASA's focus on software engineering improvements is a vital step toward achieving the systems planned for the 1990s and beyond, that a focused strategy will drive contractor response, and that appropriate cost-sharing and award incentives are the best mechanism to get rapid payback for the transition.

Lockheed

Kent Lennington, Chief Scientist, Software Support Environment, spoke for Lockheed. He said that, in general, the SSE project endorses all the recommendations and the transition model described in the report. Management and technical training are important. SSFP use of the SSE will develop an Ada support environment experience base. The SSE can serve as an example for policies and standards. The SSE will support the collection of many metrics automatically.

Lockheed made the following specific comments:

Centralized Task Forces. It is not clear how contractors or NASA projects can participate in these groups. Methods to broaden the input to these groups should be considered. Examples are periodic open meetings or workshops, wide dissemination of minutes, and solicitation of input on specific issues.

Policies and Standards. Lockheed and the SSE project support this recommendation and suggest that such policies and standards take into account

5443

DoD-STD-2167A, -2168, and related standards. Industry review of draft standards is highly desirable.

Software Development Environments. The recommendation is a good start, but it is not an Ada software support environment. It will not provide the expected benefits of an Ada software support environment.

Training. Training is essential to the success of the overall program. Separate training for managers and technologists should be considered. Because thorough training is costly but essential, some way must be found to attach incentives to it.

Software Measurement Program. The SSE project has a requirement to define and automate the collection of metrics for software development, reuse, management, and the life cycle. These metrics, when implemented, could form the basis of the recommended program. Care must be taken to keep the measures objective and confidential. They should never be used for awards.

Boeing Aerospace and Electronics

Weldon Jackson, Ada Engineering Manager, presented Boeing's response to each of the recommendations.

Ada Adoption. Boeing is committed to Ada and completely agrees with the recommendation.

SEAITF. Boeing was successful with a similar approach. The task force should have periodic reviews with the centers, and should involve DoD, industry, and academia.

Policies and Standards. Boeing agrees completely that NASA should develop and adopt tailorable standards. Standards provide stability. They should be coordinated with the DoD standards to take advantage of contractor investments in training, internal standards, and environments based on DoD standards.

Software Support Environments. An environment should support the common software development process. NASA should stress required capabilities and tool interfaces rather than specific methods or tools. Specifying specific tools may be too expensive. The approach to an environment should be evolutionary.

Transition Planning. Boeing agrees that each center should develop its own plan for evolving to Ada. The SEAITF charter should be approved by each center, and the center plans should be adapted from SEAITF policies and standards. NASA should promote DoD, industry, and academic involvement.

Training. Boeing agrees completely. The curriculum should be built around basics and should emphasize NASA's role in acquisition management. The training should be available to contractors.

19

Risk Management. Boeing agrees completely. Policies and standards should reduce risk. With policies and standards in place, risk management can focus on project-specific areas.

Contractor Incentives. Boeing feels that contractors should follow the NASA mandate without special consideration. In source selection, NASA should emphasize the contractor's ability to solve the problem, not the tools it has available. Contractors should be rewarded for creating and using reusable code.

Coordination of R&D. Boeing feels that NASA R&D should address Ada in the context of NASA applications. The DoD, industry, and academia are carrying on a great deal of Ada-related research, which NASA should take into account.

Software Measurement Program. Boeing sees a universal need to collect metrics. Metrics should be collected for both technical performance and performance with respect to contracts, costs, and schedules. Boeing's experience indicates that the establishment of a metrics program takes much effort and coordination. NASA should coordinate the program with DoD, industry, and academia.

Software Process Engineering Task Force. Boeing agrees with the idea. The task force will need instruction and training. Boeing supports the SEI assessment process.

Jackson concluded by saying that the recommendations will have minimal impact on Boeing. Boeing has implemented internal embedded software standards and a software support environment that meet DoD requirements.
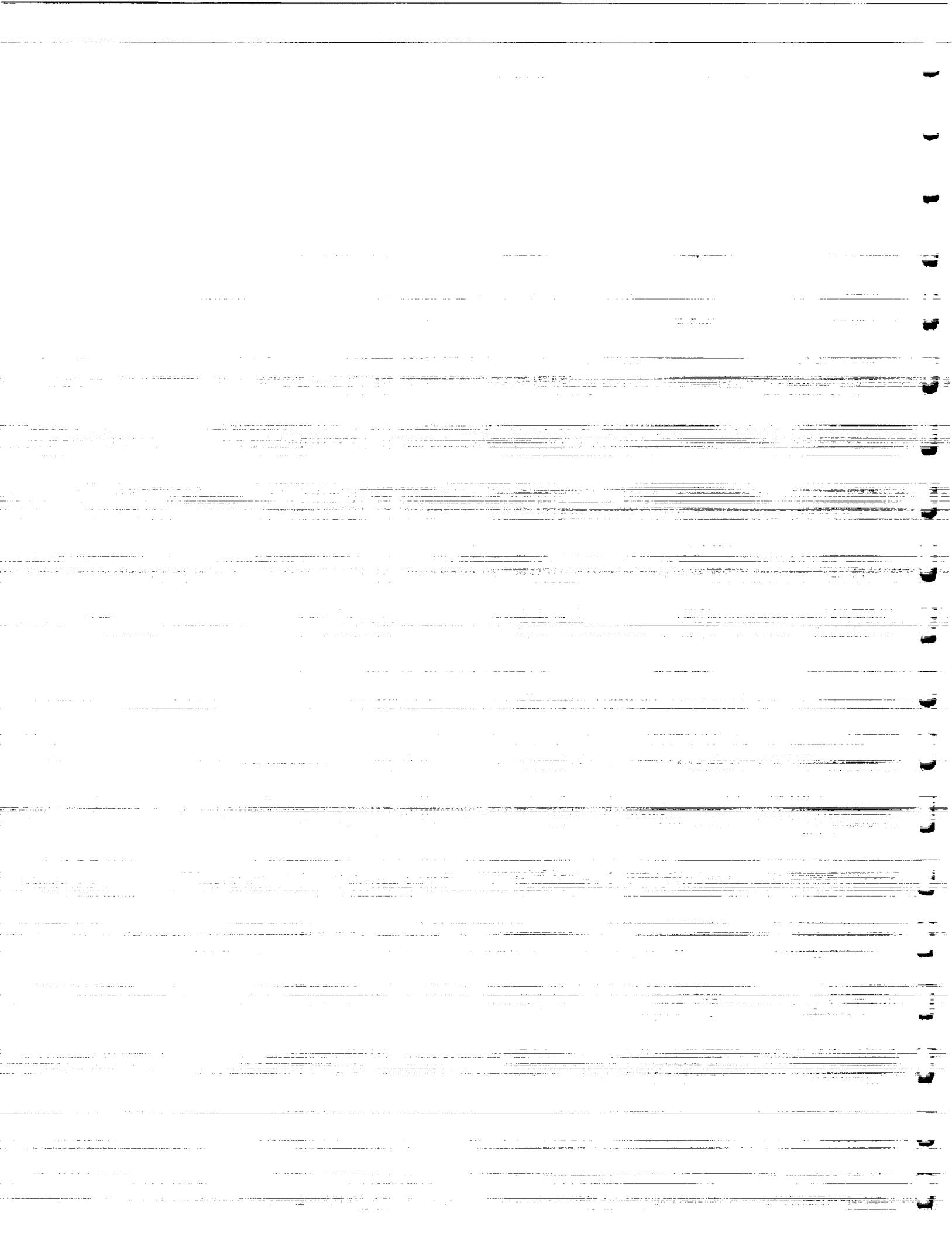
Ada AND SOFTWARE MANAGEMENT IN NASA

PANEL/FORUM: POTENTIAL EFFECTS ON NASA

A series of three panels (Sessions 5 through 7) were held on the second day of the symposium/forum, followed by a plenary session in which summaries of the day's discussions were presented.

SESSION 5

The first panel of the day was introduced by Frank McGarry. McGarry explained that the purpose of the forum was to provide the NASA delegates to the symposium with the information they would need to make recommendations to their IRM Council representatives. The panelists were to comment on the ASMAWG report, focusing on the perspective of their organizations. The session facilitator was then to invite the audience to probe the panelists' remarks by asking questions.

McGarry emphasized that the goal of the forum was to ensure that delegates from the NASA centers and program offices had the opportunity to raise all their concerns and have their questions answered.

Jack Garman, Johnson Space Center (JSC)

Jack Garman began by remarking that the meeting was extraordinary in that the agency was looking across all centers and activities. Garman noted that NASA was going through a transformation with unending programs such as the Space Transportation System (STS) and the Space Station Freedom Program (SSFP). Although SSFP depends on shuttle, and subsequent programs will depend on the Space Station, the budget has no such stair-step profile. An observer might conclude that NASA is either going bankrupt or has a strong motivation for greater productivity and efficiency. If the latter is the case, one improvement must be to lessen autonomy across centers. "If we don't figure out how to act as a team, ..." Garman said, "we're not going to have a chance at being more efficient and more productive."

Garman observed that the issue here is the technology of software development and management, not Ada. Ada, however, is the keystone. Everyone knows something about Ada; even the words *Ada* and *software engineering* tend to be used interchangeably.

Whereas in the 1970s no one at NASA headquarters was interested in software management and languages, Garman said, a number of headquarters offices now want to take charge of the agency's role in software technology. Because neither situation is optimum, JSC will push hard for a focus at headquarters. Garman felt the Software Management and Assurance Program (SMAP) and activities from the ASMAWG effort should be pulled together and put somewhere else. Without a

21

focus at headquarters, he is convinced that NASA increases its chances of diverging from government standards such as DoD-STD-2167A. The ranking organization that could provide this focus is Code N's IRM Office, which should either grow into these wider activities or should cleave them off.

Garman noted that the ASMAWG report gives one the impression that NASA writes all its own software, whereas NASA spends far more money acquiring software. NASA must also hand over software from one contractor to another to maintain. Consequently, Garman said, a clearer view of the acquisition role of the agency should be provided.

On the topic of incentives, Garman observed that they would be of greater advantage to smaller companies. Those who do not think incentives are necessary should still urge NASA to provide them. "The issue is not whether we need them, but whether they will accelerate this technology and help the industry of this country, which is one of our roles."

Sue McMahon, HQ/OSSA

Sue McMahon was the representative of the Office of Space Science and Application (OSSA). McMahon provided some background into the "culture" of OSSA which, she said, is consciously decentralized. In OSSA, the project manager has historically been king. However, in a world of SSF attached payloads and shared data analysis, they will no longer be able to work independently.

There are seven disciplines within OSSA, and these traditionally have had independent spacecraft and instruments. OSSA has 20 percent of the NASA budget, a share that McMahon said will probably rise and fall with the SSFP. OSSA is currently faced with having to turn off existing spacecraft to build funds for new projects. On projects such as the Mars Observer, OSSA is also considering taking instruments off the spacecraft so they can afford the costs of operations and data analysis.

McMahon observed that OSSA is risk-driven and, consequently, very conservative. Introducing new technology such as Ada is a risk that project managers, who bear the responsibility for the success and budget of a project, will not assume voluntarily.

McMahon displayed a viewgraph that showed the many launches of OSSA-sponsored instruments and spacecraft that are scheduled from 1989 through 1993. Recognizing that Space Station payloads and the Earth Observational System are starting to drive OSSA into a major culture change, the Associate Administrator (AA) for OSSA has initiated a study to determine a strategy and plan for prioritizing their needs. Although the ASMAWG recommendations are in budgetary competition with other equally good ideas, the timing of the report is very good.

Because of its distinctive culture, McMahon thought that mandates would not work now in OSSA. However, a recent report on the needs of OSSA scientists to the

year 2000 reads like a rationale for the ASMAWG study, she said. "We can see we're in a world where we must work together much more."

McMahon noted that there are several matrix divisions within OSSA whose job it is to make the OSSA world better. The job is a difficult one because they must show they are adding value to projects but have no independent budget or authority. In this light, the ASMAWG recommendations appear too simple: "We can't expect to give the plan to code N and Q and have it ripple through the agency." More time should be spent determining how the plan can be implemented.

Tom Thornton, Jet Propulsion Laboratory (JPL)

Tom Thornton prefaced his remarks by saying that he wanted to provide some perspective to help the audience understand how JPL will arrive at its conclusions on the ASMAWG reports. He is convinced that these conclusions will be to "fully support all recommendations and join with Goddard as an advocate of this approach to systems engineering."

Noting that the recent Magellan launch was JPL's first planetary launch in 11 years, Thornton said that one other aspect of this event was also cause for excitement: major software systems for Magellan were delivered on schedule, with full functionality and within cost. The Magellan software implementation, he said, was one of smoothest he has ever seen.

Five or six years ago, Thornton explained, a large number of software projects at JPL were in trouble. A task team was put together to examine the software engineering process. Their recommendations for standards, a software resource center, training, metrics, tools, and quality assurance (QA) closely paralleled those of the ASMAWG. The small pilot projects JPL chose to test the implementation of these recommendations have been extremely successful. "This experience will help us make a recommendation to follow through with this report," he added.

Thornton remarked that he personally believes Ada will soon be the preferred language of software engineers, although C is the current language of choice at JPL. JPL has had good experiences with Ada in developing the Global Decision Support System, of which 270 to 400 thousand lines of code (LOC) are in Ada: the cost of the project did not increase; it was easy to put in the field; and was virtually error-free. Other JPL projects under development will be implemented in Ada, and Ada training courses are progressing extremely well. "This background leads us to conclude that Ada is a good mechanism to help with software engineering methodology," he said.

Expressing concern with costs, Thornton said JPL needed some idea how much the plan would initially cost to implement. Because project managers have to accept the plan, they need to understand the effects on their costs as well.

Thornton also noted that flight project managers will want to know if Ada will improve productivity. He then described another Ada project that uses

DoD-STD-2167A, independent testing, and the methods of a good software engineering environment. This project's productivity is an order of magnitude lower than the JPL norm (2 LOC versus 20 LOC per day).

Thornton also voiced the concern that JPL would not want to use Ada for artificial intelligence and simulations. NASA needs to worry about how other languages are integrated into Ada programs, he said.

On the topic of incentives, Thornton noted that one can go from 10 LOC to 20 LOC per day by doing smart things, but you cannot go to 100 LOC per day without reuse. He would vote to change the incentive recommendation to focus it on reuse. "When you do that, you are focusing on productivity and are giving the incentive to project managers to want to follow in this direction."

Rob Kudlinski, Langley Research Center (LaRC)

Rob Kudlinski began by saying that several groups of Langley managers had reviewed the ASMAWG reports and that the recommendations were very well received. The key point of their response was that they wanted all the recommendations implemented as a package. Managers at Langley are concerned about the risks of infusing a new technology into a project. It would not do, they felt, to adopt Ada and fail to go through with the funding, training programs, or task force.

The timing of the report is excellent from Langley's perspective, Kudlinski noted, because they currently have a group that is assessing the flight software development process. Flight software projects have traditionally been small at Langley and often consist of pieces that remain after the project's hardware is engineered. With software projects now growing larger and more complex, LaRC needs a central focus for software engineering.

The recommendations of the assessment group at Langley, Kudlinski said, are similar to those of the ASMAWG. These include adopting Ada, standards, risk management plans, and metrics. Langley has started two pilot projects in Ada: one is a parallel development of a PL/M project; the other will use Ada for a long-term project that is expected to go through considerable evolution.

Kudlinski asserted that the idea of a task force was essential. The central facility would prevent the centers from duplicating the effort needed to investigate methodologies, set up standards and policies, and obtain information.

Langley is currently using SMAP's *Information Systems Life-Cycle and Documentation Standards, Version 4.3*, and is setting up a metrics program. Project managers recognize that they need help. They welcome assessment and have readily accepted standards.

Training, Kudlinski observed, is critical for Langley because few managers or programmers know Ada. Although his group is trying to establish a training program,

they have had difficulties with funding. In consequence, they believe an agency-wide program that is fully funded from the agency level would be a key element.

Kudlinski suggested that the training program include a certification program for contractors. He noted that agency-sponsored contractor training would constitute a good incentive, as would higher proposal scores given for contractor facilities and systems that support good software engineering practices.

In conclusion, Kudlinski stated that Langley supports all the ASMAWG recommendations and that his memo to the IRM Council will reflect this support. He expressed a desire to see some recommendations from the SEAITF as soon as possible, so that the tools that Langley is purchasing could be selected to fit into the common support environment and so that Langley's training courses could be made compatible with an agency-wide curriculum.

Discussion

The first issue addressed in the discussion period that followed the panel presentations was raised by Ed Seidewitz (GSFC). Seidewitz noted that although contractors wanted to go ahead with the recommendations, NASA seemed to be saying, "These sound like good ideas if you can get the project managers to accept them." If the recommendations were good for NASA as a whole, was it time for upper management to take some of the prerogative away from project managers?

Tom Thornton replied that this would not work and such an attempt would stop the plan cold. "What you've got to do," he said, "is to convince a few of the project managers there is a great benefit here. If you convince them that their job will 1) be easier and 2) be less expensive and entail less risk, then they will join forces with us."

Sue McMahon noted that a project manager must fight each year for money, and that these battles hurt planning for the use of a tool like Ada or a software engineering methodology that needs front-loaded funding. We have to help the project managers, she said, by providing them with the information that makes it easy for them to agree to the plan in view of the tough budgetary tradeoffs they have to make.

Jack Garman observed that JSC project managers are driven by the need to retain visibility into software projects and to manage risks, and that there is a growing hue and cry for synergism from the line organizations to support them. He thinks the world might be ready for a bit of "thou shalt" because it would relieve the project managers of some responsibility.

On the issue of costs to project managers, Frank McGarry remarked that there is a 10-year period in which we have to understand the implications of Ada before project managers would be told to use the language and given the reasons why. "I don't think right up front, ..." McGarry said, "we are looking to impact projects universally or at all."

25

Members of the audience commented that a new technology needs advocates who are practitioners, and that one way to attain good grass roots support for Ada is to institute a good training program because most programmers and managers will gravitate to Ada technology.

Asked whether the training recommended in the report would result in extra expense or whether it could result in savings if the centers pooled their existing educational funds, McGarry replied that, although it would be good to be able to say there would be no additional expense, at this time they just did not know.

In response to a comment by Marvin Zelkowitz, McGarry said he hoped NASA would act on the ASMAWG's recommendations; at the very least, the agency should take a position on the report. Jack Garman concurred, noting that NASA has no choice but to take action and become more efficient.

Asked how JPL enforces standards, Tom Thornton said a JPL team worked for 2 years to obtain consensus on the standards. They were then signed by the Director and put into place. The QA group, said Thornton, should not enforce standards because such actions cause conflicts. QA has an audit function; it is the line organization that enforces the use of the standards. Sue McMahon added that many previous committees at JPL had also advocated standards. It took a different JPL director to create the atmosphere in which consensus could be attained.

McGarry expressed the opinion that it was implausible to expect individual projects looking at their own worlds to come to the same conclusions about standards and Ada. Advocates who are looking at the global picture are needed. Then upper management must exert some pressure. Jack Garman said that one clever part of the recommendations was to require that each center do its own transition plan because this was a way of getting consensus. At the least, it would cause the administrators to ask where the standards were.

Eileen Quann commented that a distinction should be made between standards and guidelines. Standards tend to be overly specific and have to be scoped down by small projects, whereas guidelines are usually accepted by project managers and can be scoped up. Gary Raines said that because a project office buys systems, not software, standards for software and hardware must be compatible.

McGarry then asked the panel, "Should we have NASA-wide software standards?" Sue McMahon answered in the affirmative, adding that the SMAP standards should form the prototype version. Tom Thornton also responded with a qualified "Yes," noting that before the establishment of lab-wide standards, each JPL office had developed its own, thus inefficiently reinventing the wheel. Jack Garman said, "Yes, of course, it [having standards] is a form of corporate memory." Rob Kudlinski also said "Yes," then drew laughter by observing that "At Langley, we have carefully positioned ourselves for this by not using any standards over the years."

SESSION 6

Ed Seidewitz of GSFC introduced the members of the second panel.

John Dalton, GSFC

In his introduction, John Dalton stated that he would attempt to summarize comments from both Mission Operations and Data Systems Directorate personnel as well as from his own Data Systems Technology Division.

The real issue is effective software engineering and management, said Dalton. Although many of those for whom he spoke support Ada, some are concerned that mandating Ada would result in over-zealous enforcement of its use. The training program for software practitioners and acquisition managers is the key to achieving a middle ground, so that standards are neither ignored nor applied in inappropriate situations.

Dalton would stop short of recommending Ada as a standard. Ada should be adopted as the language of choice, realizing that it is not suited to some projects.

The answer is to provide an infrastructure rather than a policy solution, said Dalton. A task force is insufficient. An agency-wide organization such as JPL's Systems, Software, and Operations Research Center (SSORCE) or the Software Engineering Laboratory (SEL) is needed to support software engineers and to provide tools and methodologies.

Concerning the common support environment, Dalton recommended that the agency concentrate its energies on methodology and tools, and on the interfaces among those tools. He recommended that industry be encouraged "to focus...on meeting those interfaces, so that we have an environment that can grow as we get smarter."

Debbie Hahn, Kennedy Space Flight Center (KSC)

KSC has a perspective different from that represented by previous speakers, said Debbie Hahn. KSC is oriented toward mission goals rather than projects. Its mission experience has taught the center many lessons about reusability, maintainability, standards, and interfaces.

Hahn noted that designing systems to last for 30 and 40 years is new to KSC, and that the answer to doing this successfully lies in standard interfaces and standard software technology. KSC is interested in system standards because they want their systems to work. They are closely involved in the SSFP and have adopted SMAP and the Software Support Environment (SSE) toolset.

Although KSC agrees that software standards are needed, said Hahn, center personnel do not want NASA to reinvent the wheel. Most companies have been

27

required to propose software and system standards and design methodologies, and they have these in place. Industry standards, the SMAP standards, and Air Force standards could be used and refined. What NASA needs is grassroots participation to provide input and to ensure cooperation from the centers. It is also essential that standards be applicable to both large and small payloads and projects.

Hahn noted that KSC is strongly oriented toward C. They have had to build a generic checkout system on a Unix platform, and have found C to be very powerful and easy to learn. Although KSC will use Ada for the test, control, and monitor system for the SSFP, there is a lot of resistance to Ada at the center. Training is needed if the line managers are to overcome their prejudices against Ada.

Hahn felt that the SSE's goal of providing a software environment for everyone working on SSFP software is too broad. It has been difficult to get the project managers to limit the scope of the SSE so that the project is manageable.

In summary, Hahn said that KSC agrees with most of the ASMAWG recommendations, i.e., standards, metrics, etc. She suggested that there will be less resistance to these if Ada is "put away in parentheses."

Al Kopp, Telesoft (formerly of DoD)

Al Kopp opened with the explanation that he would be speaking from three different perspectives: as an Ada proponent, as a retired DoD employee (Ada Joint Program Office), and as a Telesoft spokesman. To help the audience, he had a different hat for each of these parts of his presentation.

Donning his DoD hat, Kopp noted that when the DoD was examining existing languages, they considered the same factors as the ASMAWG: e.g., the increasing complexity of software requirements, the larger percentage of systems costs attributable to software, and the shortage of software personnel. The DoD decided it needed a single language designed to meet all of its requirements. Kopp displayed charts showing the recent migration from other high-order languages to Ada. Fourth-generation languages are compatible with Ada, he added, and in the future they may be built in Ada.

Kopp observed that the DoD policy on Ada usage had evolved over the years. Ada was originally to be used for embedded systems. When Congress defined "mission-critical," it opened the scope for Ada in DoD. Under Secretary Richard DeLauer's memorandum of 1983 was a result; it designated Ada as the primary language for "mission-critical" computer resources, i.e., those used for cryptologic and intelligence activities, weapons, and command and control. The real surprise came in 1985 when the Army mandated Ada for information systems. Kopp felt that NASA might well do the same because Ada is well suited to information management systems.

Kopp stated that the technical issues DoD had to face because of the immaturity of the language no longer inhibit Ada's use. Compilers now exist that generate code

28

that performs well at runtime. NASA will still have to address other issues associated with the change to Ada, but these are manageable.

It is true, Kopp said, that Congress did not mandate Ada for the DoD. However, Ada is an important political issue because of its potential for improving performance and productivity. He expects Congress to continue to be involved with Ada through the appropriations process. In DoD appropriation bills, Congress has required the DoD to accelerate the introduction of Ada and has recently ordered it to evaluate as well as validate Ada compilers. We can expect Congress to monitor Ada technology in NASA as well, Kopp added.

Switching to his Telesoft hat, Kopp said that NASA would be moving into a strong technological base in adopting Ada. Because software accounts for 5 percent of the gross national product, Ada also has a large commercial potential. Kopp displayed several charts from the Ada Information Clearinghouse that showed Ada's growth in the academic and commercial sectors. Ada has already been successful in technology houses such as Telesoft, he said. The advantages of Ada in reuse are being seen in the rehosting and retargeting of compilers.

Kopp displayed graphs published in the *Journal of Electronic Defense* that showed that the productivity on an avionics electronics project rose over a set of builds, so that the productivity by the end of the project was higher than that associated with typical high-order languages. Telesoft also has a European partner that is introducing Ada over a range of applications. This organization has found that Ada is providing a faster return on their investment than they had expected. These examples show that Ada is profitable in either the short or long term, Kopp concluded. However, because its introduction requires a learning period and investment, help is needed in advancing Ada technology. "This is the most valuable addition that NASA's joining the Ada community can provide," he said.

Tony Carro, NASA Headquarters/Office of Space Operations (OSO)

In his opening remarks, Tony Carro commented that the ASMAWG recommendations are comprehensive and well thought out. Adopting Ada is probably a good move, he said.

Carro asked why the working group had restricted itself to mission software. Most Code T systems relate to ground systems, and it is unclear which would be considered mission software. Code T has already chosen Ada for some major projects, he noted.

Carro had several disagreements with the plan. He felt the proposed time for the transition to Ada is far too long. In addition, a fairly accurate idea of the costs of the plan is needed; training and other transition costs might be considerable and, therefore, would act as a strong deterrent.

"We're not separating the issue of standards, the issue of software engineering, and the issue of Ada," Carro objected, saying that these should be dealt with

29

individually. He was also concerned with large projects for which a language decision was needed immediately. Should we recommend Ada, or are there other options? Is it sufficient to use good software engineering principles? Carro also noted that NASA had already decided to use Ada on some large projects and asked if this might obviate case-by-case decisions on other similar projects.

Personally, said Carro, he believes Ada is a good compromise as a standard language if the appropriate waivers are granted. However, the ASMAWG made points that are not applicable only to Ada, e.g., "Ada encourages the use of software engineering, encourages reusability, and lowers the life-cycle cost." Most contractors are already using software engineering principles whether or not they use Ada, he remarked. Neither is reusability an exclusive property of Ada. Ada does not enforce reusability, which has to be designed into the system.

On the question of costs, Carro observed that "no one is giving any numbers." If the agency is going to make this major switch, it must have a precise idea of the expense. The costs of training and tools are large enough that the savings with Ada will only be realized in the future. Therefore, NASA must ensure that costs will be lower over the life of a project.

Discussion

Panel facilitator Ed Seidewitz responded to a comment from the audience that Modula and C++ as well as Ada promote productivity gains, software reuse, and engineering principles. He noted that because NASA's new projects will have lifetimes of 20 or 30 years, the agency must build software that is more reliable and maintainable. It is natural to choose a standard language, he said, and Ada is a reasonable choice. The argument is not based on the technical merits of Ada versus Modula, C, or C++ but on the DoD, contractor, and vendor support that Ada enjoys. Tony Carro voiced his agreement with this statement.

Seidewitz then asked the panel if NASA should choose a standard language at all. Debbie Hahn answered "No," noting that, for KSC's real-time control and checkout systems, Ada is more of a hindrance than a help. Hahn said she believed KSC would gain more by specifying software engineering principles.

Al Kopp said that the DoD wanted high reliability and long-term maintainability, for which Ada is the best choice. Because NASA is dealing with the same problems, he would answer "Yes" to the question.

John Dalton gave a modified "No." NASA should have the goal of using a common language and should remove barriers to achieving this by providing Ada training and other support. However, adopting a standard language would result in rote decisions. Unless managers understand how to make language decisions correctly, and unless the waiver authority is delegated to a low enough engineering level so as not to impede productivity, "we would be shooting ourselves in the foot for the sake of a standard language."

Tony Carro answered that he felt the agency needs commonality. If it continues on its current course, NASA will have the same problem with multiplicity of languages as did DoD, and reuse will suffer.. Carro said he thinks Ada is a good choice. He believes in standards as long as there can be waivers.

Jack Garman asked whether one would be using Ada if he were using a tool, such as a data base management system (DBMS) or fourth-generation language (4GL), which was implemented in Ada. Members of the audience replied in the negative, noting that a FORTRAN compiler could be written in Ada. John Dalton said that this question might illustrate the need for latitude in the language policy because people who did not understand the essence of the problem might answer the question differently. DoD's answer to the question would be "No," said Kopp. He noted that the SEI recommends keeping Ada and Structured Query Language (SQL) distinct, so that both languages remain intact and the interface between them is clean.

One attendee commented that he interpreted the report as saying that Ada would be the standard procedural language replacing FORTRAN and COBOL, but it would not be the language for special purposes such as rapid prototyping. Seidewitz agreed that there is a lot of latitude in the recommendations. He noted that the report does not suggest the use of Ada for research, management information systems, or new technology. It does not preclude the use of C++; it mentions the use of DBMSs and 4GLs; and it describes a nonburdensome waiver process.

Jeff Neufeld noted that industry pushes for a standard because it costs more to support four languages than one and that standardization always involves a compromise among capabilities. Bruce Krell expressed the opinion that commercial software vendors are going to adopt Ada to achieve reusability.

One member of the ASMAWG sitting in the audience noted that the working group had engaged in many of the same debates. The NASA mandate for research, he asserted, precludes the use of Ada alone. However, NASA's mandate for long-term missions requires the agency to use a language such as Ada because of its support for maintenance.

An audience member commented that if 4000 rather than 400 NASA personnel knew Ada, some of the fear of Ada as a standard might disappear. Another noted that his company had no difficulty with the mandate for Ada during its work on the Space Station and that the use of modeling tools instead of Ada where these were appropriate had not been questioned.

Joe McCabe reiterated that the waiver authority must be put at the project level. In the DoD, Kopp responded, "we equate program managers next to God, and they equate themselves as over God." "If God establishes the standards, then the program managers who are over God make the waivers," McCabe rejoined.

31

SESSION 7

Victor Basili of the University of Maryland introduced the last panel. Basili said he felt the report was extremely impressive and contained an iterative flavor that reflected the scientific process. He was excited that the proposed standards were tailorable at the project level and that they could evolve with experience. He suggested that a hierarchy of standards be developed, and that NASA provide examples of standards tailored for smaller projects.

Paul Smith, HQ/Office of Aeronautics and Space Technology (OAST)

Paul Smith stated that OAST agrees with all the findings of the ASMAWG, but he recommended that software engineering methodologies be considered separately from Ada as a language. Ada can serve important functions agencywide, both in methodologies and tools. Although the agency should seek environments that support Ada, these environments should be able to accommodate other languages.

Smith explained that OAST focuses on the basic research that supports the engineering of highly reliable and complex software systems. The objective of its NASA Initiative in Software Engineering (NISE) program is to develop the technologies, methods, and skills that will facilitate cost-effective development and management of reliable software that is maintainable for long periods of time.

The agency should provide incentives for software reuse, Smith said. Training is also needed to establish a knowledge base. He commented that some of NASA's requirements may not demand implementation in Ada specifically.

Smith felt that the following perceptions of Ada within the agency needed to be addressed:

- Ada compilers have had deficiencies.

- Ada is not the desired solution for real-time spaceflight applications, because they employ small onboard memories and require high execution speeds.

- Ada is not efficient for multiprocessor applications.

- Ada does not support fault-tolerant features well.

- Ada is not well received for modeling.

- C is the up-and-coming language in universities.

Smith then made several observations: NASA must employ state-of the-art software engineering practices; the agency must understand the financial impacts of the recommendations over its many diverse applications; the definition of *mission software* needs examination; and NASA needs to address the integration of other programming languages into the structure recommended by the ASMAWG.

Smith expressed doubt that universities will provide enough students trained in Ada. He stated that the agency should examine DoD's long-term projection of Ada's impact. He also asked

- Is Ada used in the commercial environment? If not, what is used and why?

- Concerning the 10-year phase-in, how long would it take for a large project to go through enough of the life cycle to demonstrate success and to provide an experience base?

- How are increased costs to be supported by projects or NASA organizations?

In closing, Smith commented that the assignments of NASA codes in the 5-year plan need to be reviewed and perhaps revised.

Dave Aichele, Marshall Space Flight Center (MSFC)

Dave Aichele observed that the ASMAWG had done "a fine, courageous job on a difficult problem." He then expressed a number of concerns.

The agency's target should be state-of-the-art software engineering practices rather than Ada, Aichele said.

Aichele took exception to the use of the word *all* in the report. He also expressed concern with the inclusion of modeling in the definition of mission software.

Aichele felt that NASA Management Instruction (NMI) 2410.6, if applied properly through a software management plan and verified by peer review, provides the agency with a sizable "leg up on where we're going to go." He would have voted "No" on agencywide standards, he said. His experience with avionics hardware standards makes him believe that standards tend to produce stagnation.

Aichele expressed the opinion that the agency needs to reestablish the systems engineering office at NASA headquarters. This, he said, is where the activities recommended in the report should be housed. He felt that little would result from a fragmented approach, i.e., assigning activities to various AAs.

The agency should have a policy that requires centers to use good, state-of-the-art, software engineering techniques tailored to the project, Aichele said. To provide some leverage from above, the policy should say that the project must consult with the software engineering office before issuing a procurement request.

In conclusion, Aichele said that when NMI 2410.6 was proposed, the response at Marshall was, "Why...do I need that for software? I don't have that for any other discipline." Aichele said he does not see much change in this attitude at the centers. Consequently, he expects management to have some objections to the recommendations.

33

Kathy Schubert, Lewis Research Center

One concern that was voiced at Lewis, Kathy Schubert said, is with the scope of "mission software." A clearer explanation of what is or is not included under this term is needed.

Personnel at Lewis feel that for small, self-contained projects, Ada may not be the best choice, Schubert said. Personally, she would wholeheartedly endorse the selection of Ada, but the term *mandate* creates resistance.

Another concern is with the costs of the program. Lewis needs an indication of what these costs are, both up front and over the long term, and of how they are going to be met.

In summary, Schubert said that her main concern is that the momentum from the meeting be carried forward into action. She said she hoped the plan would not languish because of inadequate support or funding.

Discussion

Vic Basili noted that yesterday industry had said, "Yes, let's go with the recommendations," whereas today he had heard a very conservative view from NASA. He asked the panel why there was such a difference in attitude?

Paul Smith answered that perhaps it was due to the use of the word *all* in some of the recommendations. NASA is a diverse agency, he said. It is working on large projects that can certainly benefit from the recommendations, medium projects that can benefit by some of them, and small projects that need some flexibility. Perhaps, he suggested, NASA does not want to get locked into situations that might inhibit innovation.

Kathy Schubert responded that some of the diversity might be due to lack of experience with Ada and could only be overcome by education and training.

Aichele reiterated his concern with the word *all*. He also felt that, as a buyer with the responsibility of making the project successful, NASA would naturally be more conservative than industry. One attendee noted that the industry representatives also worked on DoD contracts, and thus were already on the Ada bandwagon. NASA knows its own business but lacks this Ada exposure.

Dan Roy commented on the linguistic aspect of the discussion. "The lingua franca of science is English," he said. Although he finds it difficult to convince French colleagues to write articles in a foreign language because they have centuries of papers in French that they would like to reuse, it is the communication itself that is most important. He would not like the President of the United States to mandate English in France, but if the price of communication is to use a common language, we should welcome it.

34

Roy said that he was puzzled by the separation of state-of-the-art software engineering from Ada. "Can you tell me," he asked, "what kind of software engineering you can do without exception handling, without strong typing, without tasking and concurrency, without the concept of packages?" If you talk about software engineering, you have to consider software engineering with Ada, he said, because you cannot succeed "if you don't have support for limited private types, abstract data types, the concept of object-oriented design, and everything that we have discovered in the 15 years since C was invented to fit in the 16-bit address space of a PDP-11."

Al Kopp commented that the industry response yesterday was not at all like that of 5 or 7 years ago. To have major contractors support language standardization was a situation that NASA was enjoying uniquely and one that he wished DoD had had. A representative from industry observed that the Ada mandate applies to production software rather than for laboratory development, and that the language is very appropriate for this.

Ray Wolverton responded to an earlier suggestion that perhaps the contractors had said what they thought NASA wanted to hear. He said that this was untrue and that they had wrestled long and hard with each of the recommendations. They felt the coalescence of industry in support of the plan was a plum being handed to NASA on a silver platter.

Ed Seidewitz said that he interpreted NASA's conservatism as stemming from the worry that, on any particular project, standards will inhibit adaptation to new situations. On the other hand, the contractors who were actually going to put their business on the line by performing the work agreed that Ada should be NASA's standard language.

Basili said that it is very important to recognize that software is a part of systems engineering. He said that NASA is in the software business and that "when you talk about systems engineering and it's not software oriented, I can't even guess what you are talking about."

Ed Chevers of JSC responded that NASA has a problem with the universities. Although DoD mandated Ada years ago, fewer than 200 universities are teaching Ada, and of these fewer than 6 provide degrees in software engineering. Basili said that these comments were well taken and that universities were not yet preparing students to work in Ada. Universities, he said, are very conservative and short of the funds required to purchase the equipment and facilities that are needed. The University of Maryland has a good program in software engineering, but there are few professors in the field, and it is difficult to find a production environment on which to perform research.

In response to Paul Smith's question about the length of time needed to provide an experience base with Ada, Basili noted that NASA should be closely watching such

Ada programs as the $4 billion Advanced Automation System. Dave Aichele said that, after 3 years, Marshall had recently completed its first Ada system. This project, during which Marshall was a beta test site for the compiler in use, took 30 percent longer in design, and 300 percent longer in implementation and testing than the norm. To an attendee's comment that this was a bad example, Basili observed that it was important to expose such situations and analyze them.

One attendee remarked that if NASA were to standardize on Ada, it would need input to the Ada Joint Program Office so that the changes to the language required by the agency could be addressed. As a final comment, another member of the audience observed that a risk reduction plan was needed for all software development projects, both large and small.

PLENARY SESSION--SUMMARY

Frank McGarry introduced the plenary session with a brief summary of the forum. He noted that the first panel had addressed standards in general; the second had addressed Ada issues; and in the third session "we picked on universities" and discussed the contrasting perspectives of industry and NASA. McGarry then asked Jack Garman for his summary observations.

Jack Garman, JSC

Jack Garman suggested that the representatives exchange the comments submitted to Code N among themselves. The secretary to the IRM council, Don Adreotta, agreed with this proposal.

Garman said that although the agency has not had to act as a corporation previously, there are now many reasons for teamwork. The conservatism of NASA versus that of its contractors may be due in part to the tradition of autonomy in the agency. "Having to give a little to be part of a whole is the toughest thing any organization like NASA has to deal with. Any corporation that has been through mergers...has the same kind of problem."

John Dalton, GSFC

John Dalton said he disagreed somewhat with Garman about the reasons for NASA's conservatism. Dalton said that the comments he had received were "valid technical reservations in certain areas." People did not dispute the proposal that Ada should be the language for most of our projects in the future. It is critical, though, that NASA not overreact "as a corporation" in achieving this goal.

The panel was divided on this issue, Dalton said. Those supporting the standard say that if we do not adopt Ada as the standard language, the diversity we have today will continue. However, Dalton said, there is a middle ground between having no standard and complete diversity. Proponents also make the point that

the waiver process will deal with exceptions; Dalton said this would be true when and if the waiver process was understood.

Al Kopp gave impressive reasons for going to Ada, Dalton added, and he agrees that "Ada is the way to go." Rather than arguing about standard languages, he suggested NASA set a goal to train all programmers and managers in agency and contractor teams, starting with those doing mission support software. "If that works, and the programmers love it, we'll have achieved our goal."

Paul Smith, HQ/OAST

Paul Smith said it is clear that NASA must take action to improve its software engineering practices. He also felt the transition would require the 10 years specified in the ASMAWG plan; he did not see evidence that the agency could change much faster.

Smith recommended the agency find ways to improve software reuse. He noted that the ASMAWG recommendations need to be considered in light of budgets, organizations, phasing, and applicability to all projects. He also felt that the success of the recommendations was greatly dependent on solid and realistic implementation plans. Smith said he did not want to leave the impression he was against Ada, but the agency must understand the costs and risks.

Vic Basili, University of Maryland

Vic Basili observed that the question "Is it Ada or is it good software engineering practice?" had been raised throughout the forum. He answered that it was really the latter but that Ada supports that good practice.

The report, Basili said, accepts the fact that software engineering is an experimental science and must be studied. If NASA studies software correctly, it will produce good software engineering, an evaluation of software technologies, and good experience.

Frank McGarry

In closing, Frank McGarry said that he was impressed with the contractors who had volunteered their positions and recommendations to NASA. Industry and the ASMAWG had done their jobs, and NASA had expressed its opinion. The ball was back in the court of upper level management, center directors, and the IRM Council; it would be disappointing if they drop it.

Thanking the audience for their attendance, McGarry adjourned the meeting.

37
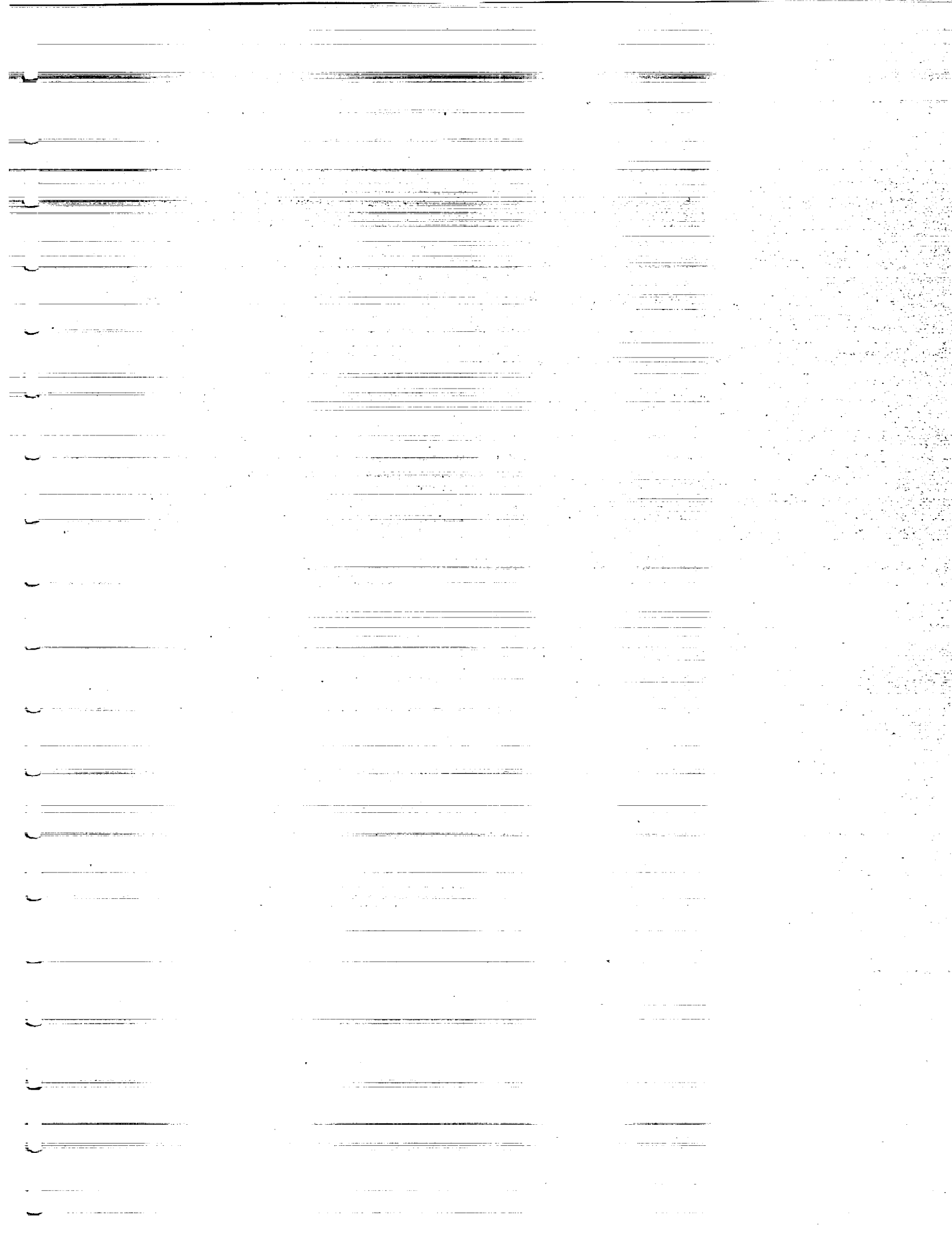
SYMPOSIUM PRESENTATION MATERIAL

This section consists of the presentation material from the first day (symposium) of the Ada and Software Management in NASA Symposium/Forum. Materials are placed in the order of presentation on the agenda.

Ada AND SOFTWARE MANAGEMENT IN NASA

Frank McGarry
Ada and Software Management
Assessment Working Group
(ASMAWG)

ADA AND SOFTWARE MANAGEMENT IN NASA SYMPOSIUM/FORUM

MAY 31 - JUNE 1, 1989

G217.001

BACKGROUND

(JUNE, 1988) NASA IRM COUNCIL ESTABLISHES ASMAWG

- ASSESS NASA POSTURE ON S/W MANAGEMENT AND "ADA" TECHNOLOGY
- DEFINE MEANS TO BUILD KNOWLEDGE AND EXPERIENCE BASE
- DEVELOP PLAN CARRYING NASA TOWARD S-O-A S/W TECHNOLOGY

(OCT., 1988) INTERIM BRIEFING (ASMAWG TO IRM COUNCIL)

(MARCH, 1989) 2 REPORTS COMPLETED

- "ADA AND SOFTWARE MANAGEMENT IN NASA - ASSESSMENT
  AND RECOMMENDATIONS

- "NASA EVOLVING TO ADA - 5 YEAR PLAN"

(APRIL, 1989) FINAL BRIEFING TO IRM COUNCIL

ACTIONS: 1. SCHEDULE SYMPOSIUM/FORUM - MAY
          2. WRITTEN COMMENTS FROM IRM MEMBERS - JULY 1989
          3. FORMULATE SPECIFIC ACTION PLAN - BY SEPT. 1989

(MAY 31, JUNE 1) SYMPOSIUM/FORUM

1. BRIEF INTERESTED AGENCY STAFF
2. "EXPLORE MANY FACETS OF MATERIAL.."
3. "PROVIDE ADDITIONAL MATERIAL - NEEDED TO PREPARE COMMENTS"

G217.003

Ada AND SOFTWARE MANAGEMENT ASSESSMENT WORKING GROUP (ASMAWG)

WORKING GROUP MEMBERS

- FRANK McGARRY (GSFC) - CHAIR
- BOB CARLSON (ARC)
- ED CHEVERS (JSC)
- LARRY FEAGAN (LeRC)
- DON SOVA (HQ)
- JOHN WOLFSBERGER (MSFC)
- ART ZYGIELBAUM (JPL)

KEY ADVISORS

- MIKE GARDNER (CSC)
- JODY STEINBACHER (JPL)
- KEIJI TASAKI (GSFC)
- SUSAN VOIGT (LaRC)

PRODUCTS

- "Ada AND SOFTWARE MANAGEMENT IN NASA: ASSESSMENT AND RECOMMENDATIONS"   3/89

- "NASA - EVOLVING TO Ada: 5 YEAR PLAN"   4/89

E217.026

WHY THE STUDY?

- CHANGING ASPECTS OF SOFTWARE AND SOFTWARE ENGINEERING TECHNOLOGY

- MANY 'PROMISES' OF 'Ada'
  1. SOFTWARE PRODUCTIVITY
  2. RELIABILITY
  3. OVERALL QUALITY

- CLAIMS THAT 'Ada' IS VERY DIFFERENT
  1. MORE THAN A LANGUAGE
  2. REQUIRES EXTENSIVE TRAINING
  3. 'NEW WAY' OF DOING BUSINESS

- MAJOR ORGANIZATIONS HAVE 'MANDATED' Ada
  1. DoD
  2. FAA (FOR AAS)

- SPACE STATION HAS 'MANDATED' Ada FOR ALL OPERATIONAL SOFTWARE

<u>BUT</u>

  1. IS NASA READY FOR Ada?
  2. SHOULD NASA BE DOING MORE?
  3. HOW WILL Ada IMPACT NASA?
  4. HOW SHOULD NASA GET READY FOR Ada?

C217.003

Ada AND SOFTWARE MANAGEMENT ASSESSMENT WORKING GROUP

APPROACH

1. REVIEW CURRENT NASA Ada ACTIVITIES

   - COMPLETED/ACTIVE/PLANNED Ada DEVELOPMENT (& STUDIES)
   - TRAINING PROGRAMS
   - SOFTWARE MANAGEMENT PRACTICES/CAPABILITIES
   - PLANNING POSTURE

   (WHAT EXISTS?/EFFECTIVENESS OF WHAT EXISTS?/WHAT SHOULD EXIST?)

2. REVIEW AND ASSESS CURRENT NASA SOFTWARE MANAGEMENT POSTURE (PROGRAMS)

   - Ada AWARENESS
   - ACQUISITION PRACTICES/CAPABILITIES
   - COMPATIBILITY WITH 'CHANGING' SOFTWARE TECHNOLOGY

3. DEVELOP AN 'Ada USE' STRATEGY

   - NASA POLICIES FOR Ada
   - TRAINING
   - PLANNING
   - RECOMMENDATIONS FOR NASA FOR Ada/SOFTWARE ENGINEERING

C217.005

SOFTWARE IN NASA

HISTORICALLY NASA HAS PRODUCED HIGH-QUALITY SOFTWARE

- NO MISSION FAILURES DUE TO SOFTWARE
- OVERALL SOFTWARE RELIABILITY VERY HIGH (FAULTS PER LINE OF CODE)
- PRODUCED SOME OF MOST COMPLEX SOFTWARE IN WORLD (E.G. SHUTTLE)
- COSTS TYPICALLY HAVE BEEN "CONTAINED"
- OFTEN ON LEADING EDGE OF SOFTWARE TECHNOLOGY

SO WHY CONSIDER CHANGE?

- EXTRAORDINARY GROWTH IN DEMAND FOR NASA SOFTWARE (AMOUNT)
- SIGNIFICANT INCREASE IN COMPLEXITY
- MAJOR ADVANCES IN AVIALABLE SOFTWARE ENGINEERING TECHNOLOGY

E217.025

SOFTWARE IN NASA

NASA HAS UNDERGONE EXTRAORDINARY GROWTH IN DEMAND FOR SOFTWARE

ATTITUDE GROUND SYSTEMS

Data points: ISEEB, SEASAT, MAGSAT, DE, ERBS, COBE, UARS, GRO

THOUSANDS OF SOURCE LINES (200, 150, 100, 50, 0)

S/W READINESS DATE (1975, 1980, 1985, 1990)

SOURCE: GSFC (SOFTWARE ENGINEERING LABORATORY)

Data points: MERCURY, GEMINI, APOLLO, SPACE SHUTTLE, SPACE STATION

MILLIONS OF OBJECT INSTRUCTIONS (0, 10, 20, 30, 40, 50, 60, 70, 80)

YEAR (1960, 1970, 1980, 1990)
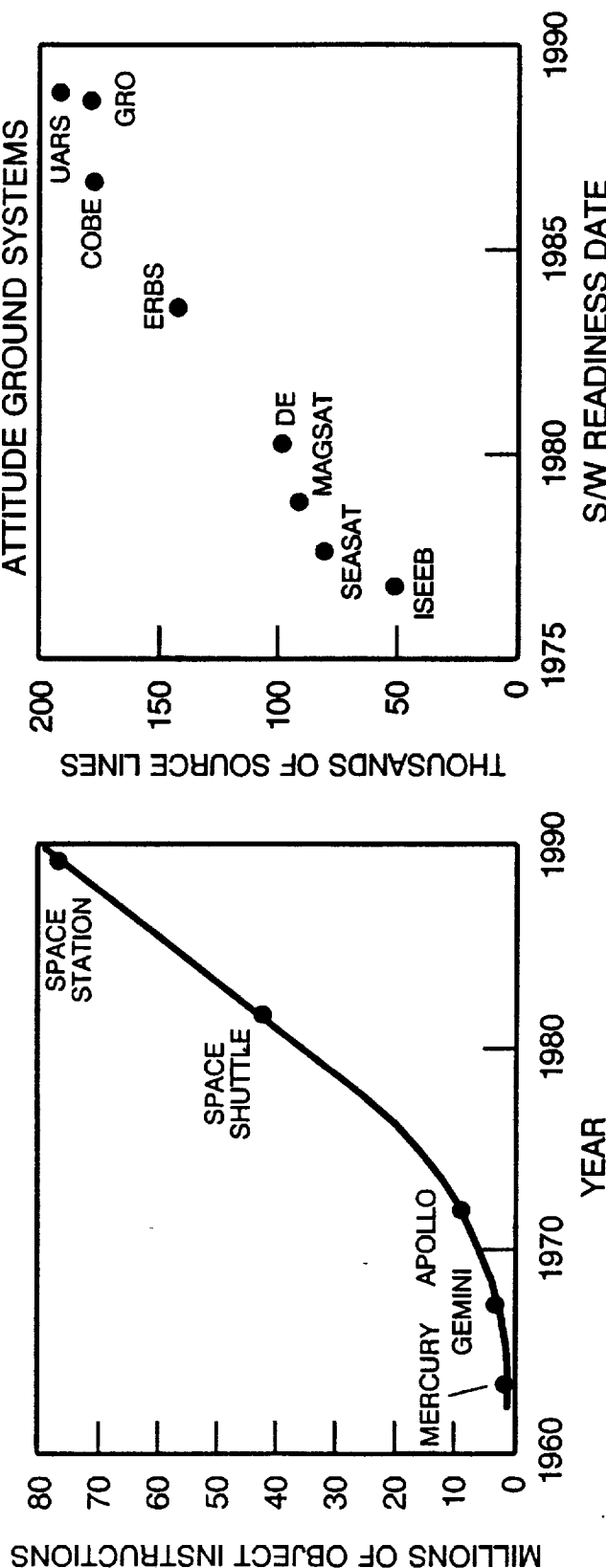
SOURCE: BOEHM (IEEE COMPUTER, SEPTEMBER 1987)

INCREASED SIZE DRIVEN BY

- COMPLEXITY OF MISSIONS
- EXPANDED FUNCTIONALITY OF SOFTWARE
- HUGE AMOUNTS OF DATA/INFORMATION

E217.024

SOFTWARE IN NASA

NASA SOFTWARE ADDRESSES MORE COMPLEX PROBLEMS

- SOFTWARE/MODELING - (E.G. AMES NAS, NUMERICAL AERODYNAMIC SIMULATION)
  (15 X 15 GEOPOTENTIAL, VS GSFC ASCF 750 X 150)

- SSF - 30 YEAR LIFETIME

- EOS, HST - EXTREME DATA PROCESSING REQUIREMENTS

- DISTRIBUTED PROCESSING (E.G. TELESCIENCE, REMOTE POCC'S)

- APPLICATIONS OF EXPERT SYSTEMS - AI

- ONBOARD SYSTEMS (E.G. APOLLO VS SHUTTLE)

- IMAGE PROCESSING SYSTEMS: SMS................ 3200 METER ACCURACY - 2D
  TOPEX............. <1 METER ACCURACY
  CRUSTAL DYNAMICS 3D

E217.023

ADVANCES IN SOFTWARE ENGINEERING TECHNOLOGY (1980's)

● ENVIRONMENTS/TOOLS
- ● "INTELLIGENT" TOOLS
- ● WORKSTATIONS
- ● GRAPHICAL ANALYSIS/DESIGN

● METHODS
- ● OBJECT ORIENTED TECHNIQUES
- ● ABSTRACTION/INFORMATION HIDING
- ● CONCEPTS OF REUSE
- ● MULTI-PROCESSOR TECHNIQUES

● MANAGEMENT TECHNIQUES/TOOLS
- ● STANDARDS
- ● LIFE CYCLE DEFINITIONS
- ● TRAINING
- ● MEASUREMENT
- ● COST/SCHEDULING ESTIMATION

● LANGUAGES
- ● Ada

E217.022

Ada
WHY DEVELOPED

PROBLEM

- DoD IDENTIFIED OVER 250 LANGUAGES IN USE FOR EMBEDDED SYSTEMS

- NO STANDARDS/COMMONALITY

- AVAILABLE CONCEPTS IN SOFTWARE ENGINNERING TECHNOLOGY (NOT BEING UTILIZED)

- 'SOFTWARE CRISES'

Ada HISTORY

1974-76 HOLWG

1977-79 DESIGN COMPETITION

1980 Ada STANDARD DESIGN (AJPO FORMED)

1982-83 FIRST COMPILERS

1983-84 DoD MANDATES Ada (STANDARD LANGUAGES)

1985 NASA SELECTS Ada FOR SPACE STATION

1985 FIRST PRODUCTION QUALITY COMPILERS (DEC)

1989 OVER 150 VALIDATED COMPILERS

C217.013

Ada IS MORE THAN A "LANGUAGE"

" Ada IS NOT MERELY A PROGRAMMING LANGUAGE; IT IS A VEHICLE FOR NEW SOFTWARE PRACTICES AND METHODS FOR SPECIFICATION, PROGRAM STRUCTURING, DEVELOPMENT, AND MAINTENANCE. WITHOUT ENFORCED USAGE OF SUCH A VEHICLE, THE RADICAL IMPROVEMENTS IN SOFTWARE ENGINEERING WILL NOT MOVE RAPIDLY INTO USE. STANDARDIZATION ON A LANGUAGE IS THE BEST WAY TO INTRODUCE THE NEW PRACTICES RAPIDLY! "

'REPORT OF THE DEFENSE SCIENCE BOARD TASK FORCE ON MILITARY SOFTWARE' 9/87 - F. BROOKS (CHAIR)

C217.012

Ada IN NASA
(4/89)

- MANDATED FOR SPACE STATION IN 1985
  - ON ADVICE OF LEADING SOFTWARE ENGINEERS
  - FOLLOWING NUMEROUS STUDIES ASSESSING Ada
  - DETAILED STUDY OF TRAINING NEED COMPLETED (11/87)

- SELECTED FOR OTHER MAJOR PROJECTS (E.G., STGT, AFE, OMV)

- APPROXIMATELY 20 COMPLETED Ada PROJECTS (500 KSLOC)
  - PRODUCED BY OR FOR NASA
  - MOST HAVE BEEN "STUDY" PROJECTS

- 100 TO 150 NEW Ada PROJECTS SCHEDULED '89 - '91 (1,200 MY)
  - 5% (EFFORT) OF TOTAL NEW NASA S/W

- NO SPECIFIC AGENCY-WIDE POLICIES/PLANS DEFINED

C217.018

IMPORTANT QUESTIONS

1. HAS NASA PLANNED FOR A TRANSITION/EVOLUTION?

2. WILL THE EXPERIENCE BASE BE THERE?

3. HAS TRAINING BEEN ADEQUATE?

4. ARE CHANGES TO NASA S/W INFRASTRUCTURE NECESSARY?

5. IS 'Ada' THE 'RIGHT' APPROACH?

C217.020

BASIS FOR REPORTS

- INTERVIEWS AND DISCUSSIONS

  - SOFTWARE/Ada EXPERTS (NASA, INDUSTRY, ACADEMIA)

- REVIEW OF COMPLETED STUDIES

  - SPACE STATION (E.G. SOFTECH REPORT)
  - FAA (FOR AAS)
  - CENTER STUDIES ON Ada
  - DoD
  - SEI

- ANALYSIS OF NASA STANDARDS, POLICIES, PROGRAMS AND SUPPORT INFRASTRUCTURE

  - SHUTTLE SUPPORT HISTORY
  - SMAP
  - SPACE STATION FREEDOM
  - TRAINING PROGRAMS
  - ADVANCED SYSTEMS (R&T)

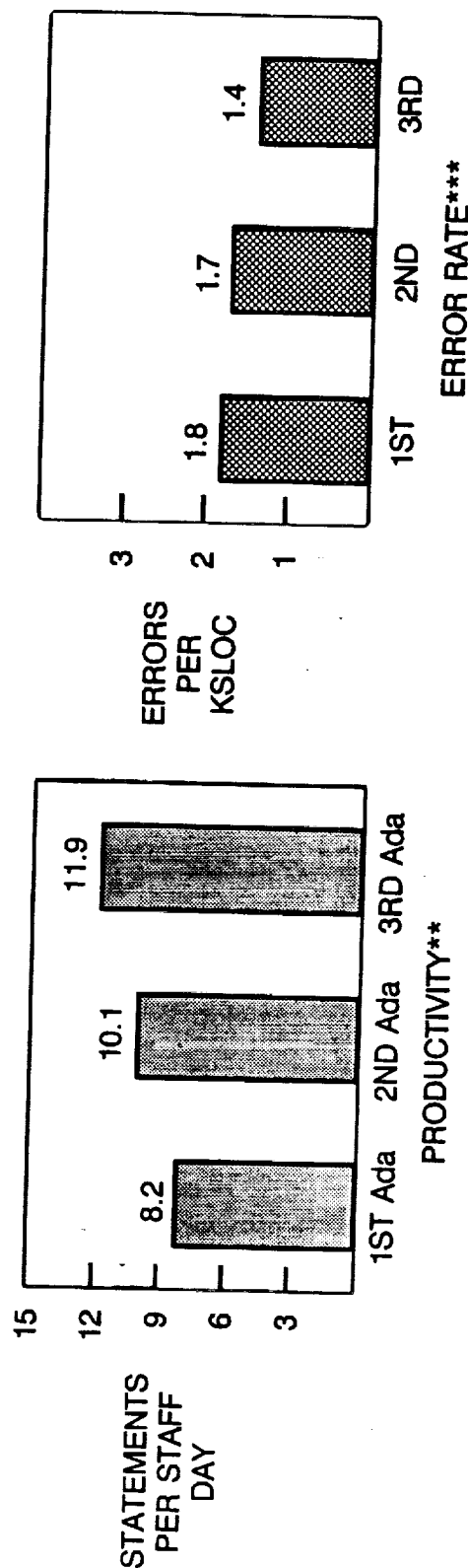- EMPIRICAL STUDIES

  - SHUTTLE
  - JPL HISTORICAL DATA
  - GSFC (SEL)
  - UNIVERSITY/INDUSTRY EXPERIENCES
  - SEI DATA

E217.021

FINDING 1

Ada IS AN APPROPRIATE VEHICLE FOR NASA
(TO SUPPORT THE EVOLUTION TO IMPROVED SOFTWARE PRACTICES)

- "BEST" AVAILABLE LANGUAGE TO SUPPORT SOFTWARE ENGINEERING TECHNIQUES
- ENCOURAGES COMMONALITY AND STANDARDIZATION
- HAS BEEN SUCCESSFULLY APPLIED IN SIMILAR APPLICATIONS (SOME EMPIRICAL STUDIES COMPLETED)*

STATEMENTS PER STAFF DAY

1ST Ada	2ND Ada	3RD Ada
8.2	10.1	11.9

PRODUCTIVITY**

ERRORS PER KSLOC

1ST	2ND	3RD
1.8	1.7	1.4

ERROR RATE***

* SOURCE GSFC (SOFTWARE ENGINEERING LABORATORY)
** TYPICAL FORTRAN PRODUCTIVITY: FROM 10 TO 12 LINES/DAY
*** TYPICAL FORTRAN RELIABILITY: FROM 2 TO 4 ERRORS/KSLOC

E217.020

ASMAWG-15

FINDING 2

CURRENT TRAINING PROGRAMS ARE NOT ADEQUATE TO ACCOMPLISH TRANSITION TO Ada

- Ada REQUIRES (RE) TRAINING OF BOTH MANAGERS AND DEVELOPERS

- SSF RECOMMENDATIONS HAVE NOT BEEN IMPLEMENTED (SOFTECH REPORT)

- NO "AGENCY-WIDE" PLAN OR CURRICULUM (Ada OR S.E. TRAINING)

- TOTAL NASA PEOPLE WITH ANY Ada TRAINING --- LESS THAN 400

- ESSENTIALLY ALL NASA Ada COURSES 3 DAYS OR LESS (SHORTER THAN RECOMMENDED)

E217.019

FINDING 3

Ada EXPERIENCE BASE IN NASA IS INADEQUATE TO MEET CURRENT COMMITMENTS
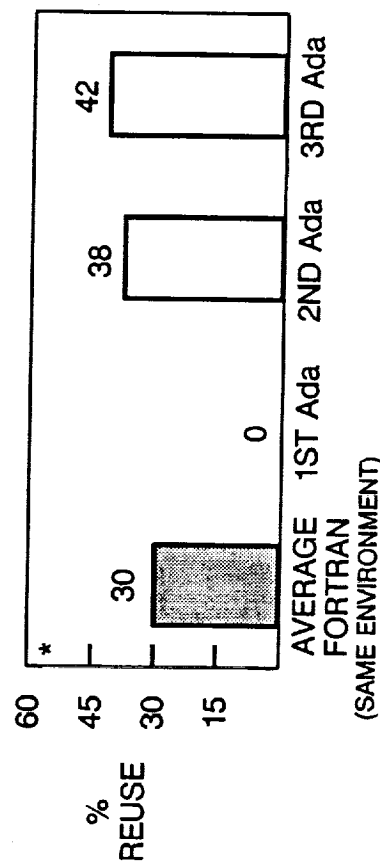
AS OF 4/89:

- COMPLETED Ada PROJECTS . . . . 20-25 (MOSTLY TRAINING)

- PROJECTED Ada PROJECTS . . . . 100-150 (MOSTLY "MISSION" SUPPORT)
  (1989 - 1991)   (ESTIMATED 1200 SY)

- ESTIMATED SOFTWARE MANAGERS/
  DEVELOPERS WITH Ada EXPERIENCE . . <2%

- SSF EARLY Ada COMMITMENT . . . . GOOD BUT....

E217.018

FINDING 4

NASA HAS BEEN ON LEADING EDGE OF SOFTWARE TECHNOLOGY USE (SOME ASPECTS COULD STILL IMPROVE)

- SSE FOR SPACE STATION FREEDOM.....S-O-A CONCEPTS

- EARLY DECISION ON Ada USE (SSF)......PROVIDED AMPLE TIME FOR PREPARATION

- SOFTWARE MEASUREMENT...........RECOGNIZED WORLD LEADERS IN FIELD

- ATOPS AT JSC..................FOUNDATION FOR Ada APPLICATION

- SHUTTLE......................S-O-A TESTING/VERIFICATION APPROACH

- REUSE HAS HIGH POTENTIAL.....BUT   NO PLANNING
  NO TOOL
  NO "ENGINEERED" LIBRARIES

%
REUSE

60 / 45 / 30 / 15

AVERAGE FORTRAN (SAME ENVIRONMENT)	1ST Ada	2ND Ada	3RD Ada
30	0	38	42

*SOURCE: GSFC (SOFTWARE ENGINEERING LABORATORY)

E217.017

FINDING 5

NASA SOFTWARE MANAGEMENT UNPREPARED IN 2 AREAS
1. AGENCY-LEVEL PLANNING FOR TRANSITION
2. RISK MANAGEMENT

● NO BROAD PLAN FOR EVOLUTION TO S-O-A TECHNOLOGY

- NO CENTER HAS GENERATED PLAN
- SSF REPORT EXCELLENT FOUNDATION - (NOT YET IMPLEMENTED)
- ATOP RESULTS NOT LEVERAGED

● RISK MANAGEMENT

- NO AGENCY-WIDE POLICY
- SMAP HAS INITIATED EFFORTS

● SSF (ONE PROJECT) HAS REQUIRED RISK MANAGEMENT
  PLANS - GOOD FIRST STEP

E217.016

FINDING 6

INFRASTRUCTURE COULD BE IMPROVED BY ADDRESSING:
1. AGENCY-LEVEL SOFTWARE STANDARDS
2. AGENCY-LEVEL INTERNAL SUPPORT ORGANIZATIONS

- ONLY EXISTING NASA SOFTWARE . . . . 1978 VINTAGE
  STANDARD IS NMI 2410.6   ONE CLASS OF SOFTWARE
                                                           GENERALLY NOT FOLLOWED ANYHOW

- SMAP ADDRESSES SOME GUIDELINES . . . . NON BINDING
                                                           OFTEN DISREGARDED
                                                           FOCUS ON "ASSURANCE"

- SSF EFFORTS ON TRAINING/STANDARDS . . . . GOOD FOUNDATION
                                                           NOT AGENCY-WIDE
                                                           NOT ADOPTED

- STANDARDS/POLICIES GENERATED . . . . TIME CONSUMING
  PROJECT BY PROJECT (SOME CENTERS   COSTLY
  HAVE CENTER-WIDE STANDARDS, E.G. JPL)   RESULTS IN INCONSISTENCY

- NO AGENCY-LEVEL ORGANIZATION FOR
  SOFTWARE ENGINEERING

E217.015

FINDING 7

NASA HAS CARRIED OUT SIGNIFICANT RESEARCH IN SOFTWARE ENGINEERING BUT TOO LITTLE IN Ada, RELATED TOPICS

- NASA HAS MADE SIGNIFICANT CONTRIBUTIONS IN S.E. RESEARCH IN PAST (RELIABILITY, TESTING/VERIFICATION, MEASUREMENT)

- ESTIMATED TOTAL EFFORTS IN Ada RELATED STUDIES LESS THAN $300K PER YEAR (T AND R)

- HAS BEEN NO GROWTH IN FUNDING FOR SOFTWARE RESEARCH (5-7 YEARS) (POTENTIAL GROWTH VIA NISE PROGRAM)

- NISE (CODE R) COORDINATES INTER-CENTER S/E RESEARCH BUT HAS NO PLANS TO ADDRESS Ada

- WITH GROWTH "IMPORTANCE" OF SOFTWARE - ADDITIONAL RESEARCH IS JUSTIFIED

E217.014

FINDING 8

NASA DOES NOT HAVE AN ADEQUATE SOFTWARE MEASUREMENT PROGRAM

- SSORCE (JPL) AND SEL (GSFC) HAVE DONE WELL . . . LOCALLY

- TOO FEW MAJOR PROJECTS REQUIRE INFORMATION COLLECTION

- NO STANDARDS/POLICY FOR MEASUREMENT

- HISTORY OF COST/RELIABILITY/TECHNIQUES RARELY AVAILABLE

- VERY LITTLE RATIONALE FOR USE OF SPECIFIC TOOLS, METHODS, PRACTICES

E217.013

FINDING 9*

NASA HAS NO ORGANIZATION CHARTERED
TO ADDRESS AGENCY-WIDE SOFTWARE
ENGINEERING POSTURE/POLICIES

- RELEVANT SOFTWARE ISSUES

  - STANDARDS/POLICIES
  - AGENCY PLANNING
  - MEASUREMENT
  - PROCESS ASSESSMENT
  - "TASK FORCES"

- CODE Q RESPONSIBLE FOR S/W <u>ASSURANCE</u>

  - NOT S/W STANDARDS
  - NOT S/W ENGINEERING

- OFFICE OF CHIEF ENGINEER (OLD CODE D) HAD SUCH A CHARTER

- AN AGENCY FOCUS IS EXTREMELY IMPORTANT AT THIS TIME

  - RAPID GROWTH IN DEMAND FOR S/W (10-20% NASA BUDGET)
  - DYNAMICS OF SOFTWARE ENGINEERING TECHNOLOGY
  - RELATIVE "YOUTH" OF SOFTWARE ENGINEERING
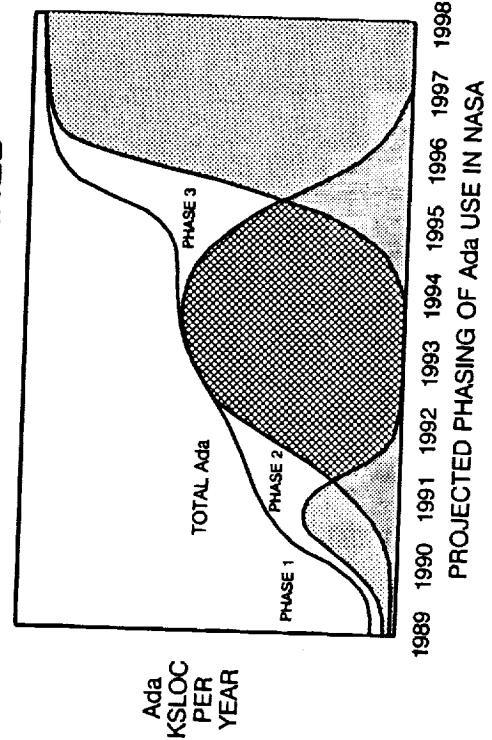   (VERY FEW UNDERLYING PRINCIPLES (SO FAR))

* NOT ADDRESSED IN FINAL "REPORT"
  IDENTIFIED DURING 5 YEAR PLAN DEVELOPMENT (AFTER REPORT)

F217.002

RECOMMENDATIONS

ADOPT Ada FOR ALL MISSION SOFTWARE

RESPONSIBILITY - CODE NT

● MANDATE Ada FOR ALL "MISSION" SOFTWARE (VIA NMI)

● ALL NEW DEVELOPMENT IN Ada BY 1998

● 3 PHASED IMPLEMENTATION
   - PHASE 1 - PILOT PROJECTS/EXPERIMENTS
   - PHASE 2 - SELECT PRODUCTION PROJECTS
   - PHASE 3 - ALL "MISSION SOFTWARE"

● PERIODIC (RE) ASSESSMENT

● EXPLICIT WAIVER POLICY DEFINED

Ada
KSLOC
PER
YEAR

TOTAL Ada

PHASE 1

PHASE 2

PHASE 3

1989 1990 1991 1992 1993 1994 1995 1996 1997 1998

PROJECTED PHASING OF Ada USE IN NASA

①

E217.011

RECOMMENDATIONS

②

DEVELOP PLANS FOR EVOLVING TO Ada
RESPONSIBILITY - CENTER DIRECTORS

- EACH CENTER TO PRODUCE TRANSITION PLAN

- DEFINE TRAINING/PHASING APPROACH

- DEFINE MEASUREMENT, CONTINGENCY

- SUPPORTED BY "Ada AND SOFTWARE ENGINEERING IMPLEMENTATION TASK FORCE" (REC#3)

E217.012

RECOMMENDATIONS

ESTABLISH SOFTWARE ENGINEERING AND Ada IMPLEMENTATION TASK FORCE (SEAITF) RESSPONSIBILITY - CODE NT

- OVERALL SUPPORT FOR Ada TRANSITION
  - CONSULTANTS FOR MANAGERS AND DEVELOPERS
  - INFORMATION CENTER
  - GUIDANCE FOR CENTER TRANSITION PLANS

- TRACK AND REPORT EVOLVING USE OF Ada IN NASA

- STIMULATE Ada TECHNOLOGY INTERCHANGE

- ADVISE ON Ada/SOFTWARE ENGINEERING TRAINING

- COLLECT AND TRACK SOFTWARE METRICS

- STAFFED WITH CENTER EXPERTS (ROTATING)
  - MANAGED BY HQ OFFICE

(3)

E217.009

RECOMMENDATIONS

ESTABLISH SOFTWARE PROCESS ENGINEERING TASK FORCE

RESPONSIBILITY - CODE NT

(4)

- SIMILAR CONCEPT TO SEI PROGRAM

- INTERNAL ASSESSMENT OF SOFTWARE ENGINEERING MATURITY LEVELS

  - START AT CENTER LEVEL
  - EVOLVE TO SMALLER ORGANIZATION (E.G. DIRECTORATE)

- EMPHASIS IS "STIMULUS FOR GROWTH" NOT "AUDIT/ PERSONAL EVALUATION"

- TRAIN ADDITIONAL CENTER PERSONNEL TO CONDUCT ASSESSMENT

- ASSESSMENT REPORTS GO TO SUBJECT ORGANIZATION FOR ACTION

E217.010

RECOMMENDATIONS

DEVELOP SOFTWARE STANDARDS

RESPONSIBILITY - CODE QR

- PRODUCE AGENCY-WIDE STANDARDS FOR ALL NASA SOFTWARE

- ADDRESS MANAGEMENT, DEVELOPMENT, ACQUISITION, AND ASSURANCE

- TAILORABLE - (NOT OPTIONAL)

- FOCUS ON "PRODUCTS" OF DEVELOPMENT (BUT PROCESS NOT TO BE IGNORED)

- INCORPORATE INDUSTRY SUGGESTIONS FOR CONTENTS

- EVOLVE TOWARD COMMONALITY (ELIMINATE MULTIPLE TRAINING, ENVIRONMENTS, PROCUREMENT PROCESS...)

⑤

E217.007

RECOMMENDATIONS

(6)

REQUIRE RISK MANAGEMENT FOR "CRITICAL" SOFTWARE
RESPONSIBILITY - CODE QR

- INCORPORATE REQUIREMENTS AS PART OF NASA/SOFTWARE STANDARDS

- RISK MANAGEMENT PLANS TO ADDRESS SUCH ISSUES AS PERFORMANCE, STAFFING, OR SYSTEM AVAILABILITY

- PLANS APPROVED AT CENTER LEVELS

- NECESSARY "NOW"

  - EVOLVING TECHNOLOGY
  - CRITICALITY OF SOFTWARE
  - COMPLEXITY ISSUES

- "CRITICAL" TO BE DEFINED BY QR (PART OF SOFTWARE STANDARDS)

E217.008

RECOMMENDATIONS

DEVELOP A NASA SOFTWARE ENVIRONMENT

RESPONSIBILITY - CODE RC

⑦

- DRIVEN BY NASA STANDARDS, PRACTICES AND NEEDS (REFLECTS NASA "METHODOLOGY")

- CHARACTERIZED BY FUNCTIONAL CAPABILITIES, PRODUCTS, AND INTERFACES

- NO HARDWARE DICTATED

- EXTENSIVE RESEARCH REQUIRED

  - THE NEED
  - RESEARCH AND FEASIBILITY
  - PROTOTYPING
  - INTEGRATION

- BOTTOM-UP "IMPLEMENTATION" (START SMALL AND BUILD UP)

- GAIN LEVERAGE FROM SSE (AT LEAST LESSONS LEARNED)

- FUNCTIONAL REQUIREMENTS EVENTUALLY IMPOSED (IN HOUSE AND CONTRACTED SOFTWARE)

E217.005

RECOMMENDATIONS

EXPAND SOFTWARE RESEARCH

RESPONSIBILITY - CODE RC

(8)

- AMOUNT OF SOFTWARE (ENGINEERING) RESEARCH SHOULD INCREASE

- Ada/SOFTWARE ENGINEERING RESEARCH - APPLIED (NOT BASIC)
  - TRAINING
  - ENVIRONMENTS
  - PROCESS IMPACTS
  - STANDARDS NEEDS
  - MANAGEMENT IMPACTS

- THRUST FOR Ada/S.E. SHOULD BE ON EXPERIMENTATION/ DEMONSTRATION

- NISE (CODE R) - EXCELLENT CONCEPT, SHOULD BE CULTIVATED

- EXTEND RESEARCH (CODE R) TO ISSUES OF INTEGRATED SOFTWARE ENVIRONMENTS

E217.006

RECOMMENDATIONS

DEVELOP NASA SOFTWARE TRAINING PROGRAM
RESPONSIBILITY - CODE ND

- PRODUCE AGENCY-WIDE CORE CURRICULUM (DEVELOPMENT, MANAGEMENT, Ada, SOFTWARE ENGINEERING)

- DEFINE SPECIFIC TRACK FOR DEVELOPERS AND MANAGERS (REQUIRE PARTICIPATION)

- MAKE AVAILABLE TO NASA AND CONTRACTORS

- SSF STUDY (SOFTECH) EXCELLENT STARTING POINT

- OTHER EXCELLENT MODELS EXIST (E.G. JPL FOR MANAGEMENT, TRW FOR Ada/S.E.)

9

E217.003

RECOMMENDATIONS

ESTABLISH AN INCENTIVE PROGRAMS FOR SOFTWARE CONTRACTORS

RESPONSIBILITY - CODE H

- MAKE Ada/S-O-A PRACTICES TRANSITION ATTRACTIVE:

  - USE OF Ada
  - TRAINING
  - STANDARDS
  - METHODOLOGIES

- DISINCENTIVES CURRENTLY EXIST: (E.G. REUSE)

- BUILD ON POTENTIAL LEVERAGE:

  - AWARD FEES
  - SHARE TRAINING COSTS
  - SHARE TECHNOLOGY ACQUISITION COSTS

- PROPOSAL SCORING CONSIDERATION:

  - SIMILAR TO SEI PROCESS ASSESSMENT
  - USE OF DEMONSTRATION PROBLEMS

(10)

E217.004

RECOMMENDATIONS

ESTABLISH SOFTWARE METRICS PROGRAM
RESPONSIBILITY - CODE NT

(11)

- BUILD AGENCY-WIDE SOFTWARE MEASUREMENT EFFORT

- APPLY TO ALL "MISSION" SOFTWARE

- FOCUS ON:

  - COST
  - QUALITY
  - TECHNOLOGY IMPACTS

- SUPPORT THE SPETF (RECOMMENDATION 4)

- SMALL IMPACT TO "MISSION" SOFTWARE PROJECTS

E217.002

SUMMARY

● NASA HAS BEEN EXTREMELY SUCCESSFUL IN SOFTWARE ARENA:
  - CONTINUALLY ON LEADING EDGE OF SOFTWARE TECHNOLOGY
  - NO MAJOR PROBLEMS DRIVING CHANGE TO SOFTWARE POSTURE

● ROLE OF SOFTWARE CURRENTLY UNDERGOING DRAMATIC CHANGE:
  - SIZE/COMPLEXITY DEMANDS
  - SOFTWARE TECHNOLOGY AVAILABILITY (E.G. Ada)

● "Ada" IS APPROPRIATE MEANS TO SUPPORT EVOLUTION TO S-O-A PRACTICES

● Ada LANGUAGE ITSELF WOULD NOT MAKE SIGNIFICANT FAVORABLE IMPACT

● Ada IN NASA (1989):
  - KNOWLEDGE BASE EXTREMELY SMALL
  - EXPERIENCE BASE EXTREMELY SMALL   } BUT THIS IS UNDERSTANDABLE
  - INFRASTRUCTURE NOT READY FOR Ada

● NASA SHOULD IMPLEMENT SIGNIFICANT CHANGES TO SOFTWARE POSTURE/POLICIES:
  - ADOPT Ada
  - CARRY OUT EVOLUTION TO S-O-A SOFTWARE PRACTICES

E217.001

MANAGEMENT QUESTIONS

- **COST (OF IMPLEMENTATION)**
  - YES - WILL BE COST
    (R & PM AND R & D)
  - CANNOT PUT $ FIGURE ON TOTAL PLAN
  - WILL HAVE UP-FRONT AND RECURRING
    (E.G., DEVELOP STANDARD MEASUREMENT)
  - NASA CAN AFFORD THIS
    - BIGGEST ISSUE IS R & PM NOT R & D

- **PAY BACK (BENEFIT)**
  - OVERALL S/W BUDGET WILL NOT DECREASE
  - WILL OBSERVE INCREASE IN S/W:
    - FUNCTIONALITY
    - RELIABILITY
    - DURABILITY
  - COST PER EQUIVALENT FUNCTION
    WILL DECREASE SIGNIFICANTLY
    [MORE BANG FOR THE BUCK]

- **PRIORITIES (IN PLAN)**
  - PLAN IS INTEGRATED
    - DANGEROUS TO "PICK AND CHOOSE"
  - AMOUNT OF COMMITMENT CAN BE SET FOR SOME
    (E.G., RESEARCH, ENVIRONMENT)

- **INTERDEPENDENCIES**
  - THEY EXIST - BUT FAIRLY OBVIOUS

F217.003

RESPONSE TO RECOMMENDATIONS: Ada AND SOFTWARE MANAGEMENT IN NASA

Ray Wolverton and Bruce Krell

Hughes

RESPONSE TO RECOMMENDATIONS:

Ada AND SOFTWARE MANAGEMENT IN NASA

Hughes Team: Bryce Bardin, Bruce Krell, Saul Volansky, Ray Wolverton
for NASA/GSFC Conference, Greenbelt, MD, 31 May - 1 June 1989

Presented by:
BRUCE E. KRELL

31 May 1989

HUGHES

RESPONSE SUMMARY

Strong support for entire plan:

- Recognizes rapidly growing contractor capability

- Reflects similar activities within Hughes

Target date - 1998 - is conservative.

Commentary based on experience within Hughes programs:

LHX: Lightweight Attack Helicopter

HS601: Three Axis Stabilized Communications Satellites

AAS: FAA Advanced Automation System

STANDARD PROGRAMMING LANGUAGE

Recommendation: NASA should adopt Ada as its standard programming language.

Response: We agree with an evolutionary plan to adopt Ada.

Comments: Other NASA programs will benefit from Space Station efforts:

- Procured software

- Development environment

Most major contractors developing in Ada for DOD:

- Major investments in Ada based S/W development technology

- Building extensive experience base

Major products at Hughes use Ada -- LHX, HS601, FAA/AAS:

- Current major new business initiatives

- Use on 2 programs is voluntary

Members of Hughes staff involved in national Ada community.

HUGHES

STANDARD PROGRAMMING
LANGUAGE (cont'd)

Comments (cont'd):   Characteristics of language ease tailoring of existing Ada software:

- Modification of hardware interface specifications

- Some programs have experienced up to 50% reuse

Institute waiver process:

- Large body of legacy code

- Place approval authority at appropriate level

3

SOFTWARE ENGINEERING TASK FORCE

HUGHES

Recommendation: NASA should establish a Software Engineering and Ada Implementation Task Force (SEAIT).

Response: We agree since effectiveness of Ada depends on robust software engineering.

Comments: Organizational sponsor needed to accomplish major changes.

Provides a source of expertise/guidelines/procedures for programs transitioning to Ada.

Similar efforts being accomplished by DOD:

- JIAWG (Joint Interoperability Avionics Working Group)

- Specify common avionics software functionality

- LHX, ATF, ATA

H-5

4

TAILORABLE STANDARDS FOR SOFTWARE DEVELOPMENT

Recommendation: NASA should develop and adopt tailorable standards for software development, management, and assurance.

Response: We agree since standards necessary to facilitate communications between contractors and NASA.

Comments: Enhances repeatability and predictability of software development process.

Contractors support concept of standards:
- Regularly work with standards
- Methodologies/processes usually based on standards

Must be tailorable:
- Inability to delete nonessential elements is costly
- Failure to incorporate essential elements also costly

Corporate participation in formulation of standards is extensive:
- Member, Software Productivity Consortium
- Resident Affiliate, Software Engineering Institute
- Tailoring of MIL-STD-2167A on existing programs

H-6

5

COMMON SUPPORT ENVIRONMENT

Recommendation: NASA should evolve toward a common software support environment.

Response: We agree with concept of functional commonality.

Comments: Commonality should be specified in terms of functionality:

- Specific technologies rapidly evolving

- Marketplace will migrate toward best tools available

- NASA will benefit by having contractors make maximum usage of existing resources

Examples of functional commonality:

- Traceability from requirements to code

- Host/Target System debugging capabilities

- Network transparency of various host environments

H-7

6

CENTER PLANNING

Recommendation: Each center should develop a plan for evolving to Ada.

Response: We agree since effective software engineering and Ada usage must reflect specific missions and applications.

Comments: Plans should reflect the needs of individual NASA centers and missions.

Individual Groups within Hughes did same -- emphasis on different characteristics of language and support environments in individual product lines.

Transition will not occur without upper level and project management level of support.

CORE CURRICULUM IN SOFTWARE ENGINEERING

HUGHES

Recommendation: SEAIT should ensure development of a core curriculum in software engineering and Ada. Each center should adapt the core curriculum to its specific needs.

Response: We agree with a curriculum emphasis on software engineering principles as the key driver in Ada development.

Comments: Hughes Core Curriculum: Ada Programming
Concurrency in Ada
Real-Time System Design in Ada

Support courses can be tailored to specific product lines and to particular characteristics of language and support environments.

Prime Courses: HS601   -   Ada Programming, Real-Time
System Design in Ada

LHX   -   Ada Programming, Real-Time
System Design in Ada

FAA   -   All Three Courses

Training must be followed by use to be effective.

H-9

8

RISK MANAGEMENT PLAN

Recommendation: For any "critical" project, management should be required to develop and implement a written risk management plan.

Response: We agree since this practice is routine for us.

Comments: Hughes company policy GM-20 requires "Risk Management Plan" for all programs.

Perceived risks of transitioning to Ada:

- New language with limited customer, contractor experience

- New compilers -- recently becoming error-free, efficient

- Little costing experience

- Real-time performance hardware interfacing usage varies across compilers

9

H-10

HUGHES

Ada INCENTIVE PROGRAM

Recommendation: NASA should establish an Ada incentive program for its software contractors.

Response: We disagree for large system houses; however, contractual terms should reflect underlying Ada methodology.

Comments: Feel that combination of a robust system engineering methodology with Ada as a development language assures delivery of effective, working systems.

Incentives are most useful for acquiring reusable software (non-optimized) and for smaller companies not currently committed to Ada usage.

SOFTWARE R&D SUPPORT FOR Ada

HUGHES

Recommendation: The Office of Aeronautics and Space Technology should plan and coordinate agency wide software R&D, more of which should support Ada.

Response: We agree since coordination improves Ada technology infusion process.

Comments: More Ada support within NASA accelerates time frame for Ada implementation.

Provides centralized NASA points of contact in key technology areas; e.g., Ada, DBMS, reuse library.

H-12

11

COLLECT SOFTWARE METRICS

HUGHES

Recommendation: NASA should establish an agency-wide program to collect and use software metrics.

Response: We agree since metrics necessary to manage software development process.

Comments: Useful in monitoring and improving development process.

Important to validate claims that combination of robust software engineering and Ada usage can deliver effective, lower life-cycle-cost systems.

Employ phased approach beginning with small number of key statistics.

IMPROVE DEVELOPMENT PROCESS

Recommendation: NASA should establish a Software Process Engineering Task Force to support the evaluation and improvement of software acquisition and in-house development processes.

Response: We agree, as natural conclusion from previous comments.

Comments: Characteristics of Ada require a strong methodology for effective use.

"Ada is more than a language"

Assures highest quality, functionally correct software to be developed.

Necessary to demonstrate that complicated, real-time, embedded system will perform functionally, as required.

Hughes accomplishing this via Engineering Councils, SPS, SEI participation.

13

HUGHES

CONCLUSIONS

- Our experience is that coupling a robust system/software engineering methodology with Ada as a development language assures delivery of effective, lower life-cycle-cost systems.

- No other incentives are necessary to motivate us to adopt this combination. However, funding profile will exhibit more front-end loading.

- Transitioning to this approach to system development does imply a learning curve at all levels -- executives, managers, technical staff, operations staff.

- This transition should evolve over time and be well-planned via both education and practical experience.

IBM RESPONSE TO ASMAWG RECOMMENDATIONS

Judy Fleming
IBM

IBM Response to ASMAWG Recommendations

31 May 1989

Judy K. Fleming

IBM

SID Houston

IBM Response to ASMAWG Recommendations

- General Observations

- Ada Adoption

- Software Engineering and Ada Implementation Task Force

- Policies and Standards

- Software Development Environments

- Training

- Risk Management

- Contractor Incentives

- Software Measurement Program

- Summary

General Observations

- Common Experience within IBM

  o Similar growing pains, assessment of situation, plans to alleviate

  o Recognition of movement to new software engineering process (technologies and tools) as much as to new language

- NASA role: acquire or perform Ada development?

  o ACQUISITION versus PERFORMANCE (viz. JSC) requires a different focus in training plan, standards, development environment

  o Monitoring, deliverables

- SSFP implications: schedule acceleration, ideal testbed

  o Ada selection demonstrates ENORMOUS commitment by NASA

  o Opportunity to accelerate 5-year plan milestones

  o Existing mechanisms to attack several objectives

IBM

- SSE Leverage

  - Use it as prototype development environment

  - Learn from it

  - Focus reuse and measurement activities on it

- Build on considerable work already done by contractors, academia, SEI, DoD, STARS, etc. in most everything

  - Curriculum

  - Metrics

  - Reuse

  - Interface standards

Ada Adoption

- Establish strategy on use of pre-existing, non-Ada code and COTS software

  - Appropriate usage

  - Incorporation techniques

- Identify acceptable special purpose languages

  - 4GLs for data base interfaces

  - Non-procedural languages for AI, expert systems

- Use R&D effort to enhance coexistence of special languages with Ada

Software Engineering and Ada Implementation Task Force

- Good mechanism to spread "lessons learned" across NASA

  ○ IBM's Ada Steering Group serves similar purpose: institutionalize what works well, discard what doesn't, share as much as possible

- Could be NASA pipeline to DoD, SEI, STARS, etc.

- IBM would like to participate

  ○ Infuse "LL" from FAA Advanced Automation System (large Ada program about three years ahead of SSFP)

  ○ Share recent work in tailoring procedures

IBM

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Policies and Standards

- Agree with idea of tailorable standards

- Recommend agency-wide focus on review points (entry/exit criteria, especially "red flags"), measurements, reuse, deliverables and their format

Software Development Environments

- Ultimate prototype in process: SSE

  o NASA is too far down the pike to invest in another prototype

  o Learn from it and drive it (especially for metrics, reuse, "integration" of software deliverables)

- Good approach for common environment

  o Functional capabilities rather than specific tool set on specific platform

  o Recommend defining framework via interface specifications, as consistent with industry standards as practical (STARS is moving this way)

  o Concentrate on maintainability, portability, and reusability for NASA without limiting contractors in use of latest/greatest/favored tools and technology

Training

- Reasonable approach

- Additional project-specific education will be needed

- Access to cadre of experts would enhance OJT, following classes

  - Ada Center of Competence

  - SWAT team

Risk Management

- Risk management plan required for SSFP

- Add Ada-specific content

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Contractor Incentives

- Ada readiness is intrinsic to proposal evaluation process

- Probably unnecessary this late in the game for NASA to "share" training costs

- Focus on reuse incentives

    o Make it financially rewarding in the near-term to reuse rather than rebuild

    o As reuse becomes a way of life, contractors will naturally migrate to it to reduce costs

    o Currently, the more you build the more money you make!

- Recognize life-cycle shifts implied by Ada, proper software engineering practices, reuse, prototyping

Software Measurement Program

- Drive SSE requirements to match NASA-wide needs

  o Plans exist for tool support of collection of wide range of software metrics

- Involve JPL software cost engineering folks

  o Historical data (for flight systems) and a proven methodology for collection and analysis

- Take advantage of SEI Measurement Task Force

IBM

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Summary

- Leverage SSFP (and SSE) as data source and prototype

- Capitalize on activities in larger Ada world

  o Spend NASA's money on space!!!!

- Share experiences and institutionalize technology infusion

Addendum to IBM Response

(Additional recommendations made during presentation)

- Use NASA R&D (or other funding approach) to attack NASA-specific needs

  - Analysis tools such as those built for HAL on Shuttle (e.g., HALSTAT, disassembler, Simulation Data Files)

  - Simulation and testing interfaces (e.g., to allow data access during simulation executions)

- More extensive knowledge of Ada within NASA would facilitate acceptance of the language in design articles and could thereby reduce documentation and review costs

- Consider how many different development environments and unique tools NASA can afford to support for programs requiring long-term maintenance

Ada AND SOFTWARE MANAGEMENT IN NASA: ENDORSEMENTS AND CONCERNS

Dick Taylor
Computer Sciences Corporation

ADA AND SOFTWARE MANAGEMENT IN NASA
SYMPOSIUM AND FORUM

MAY 30, JUNE 1, 1989

ENDORSEMENTS AND CONCERNS

CSC Computer Sciences Corporation

OVERALL IMPRESSION

- THOUGHTFUL

- CANDID

- ACCURATE

- WELL DONE

- RATIONAL BASIS FOR BEGINNING

SOFTWARE ENGINEERING OBSERVATIONS

- CENTRAL TO BUILDING CURRENT AND FUTURE SYSTEMS

- FUTURE SUCCESSES INCREASINGLY DEPENDENT ON GREATER DISCIPLINE, QUALITY, PRODUCTIVITY

- PRODUCTION OF NEW SOFTWARE ENGINEERS FALLS SHORT OF DEMAND

- LONG-TERM VIEW MANDATORY TO ACHIEVE SIGNIFICANT CHANGE

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System Sciences Division

CSC

0222(S)-2

KEY THRUSTS TO GREATER QUALITY/PRODUCTIVITY

- COMMITMENT TO SOFTWARE ENGINEERING PRINCIPLES

- STANDARDIZATION WITHOUT EXCESSIVE CONSTRAINT

- TRAINED AND MOTIVATED PEOPLE

- MEASUREMENT – DEFINITION, COLLECTION, EVALUATION, AND FEEDBACK

- RESEARCH AND DEVELOPMENT

- SOFTWARE REUSE

ADA ADOPTION BY NASA

- CSC SUPPORTS

  - STANDARDIZATION FOCUS
  - MATURING TECHNOLOGY OF THE FUTURE
  - SOFTWARE ENGINEERING SUPPORT
  - PERSONNEL GROWTH, RETENTION
  - PROMISE OF REUSE

- CAVEAT

  - STANDARDIZATION SUPPORTED BY TRAINING
  - TRANSITION SUPPORTED WITH LONG-TERM VIEW
  - RISKS, RESOURCE NEEDS, SCHEDULE IMPACT
    EXPLICITLY TREATED IN PROCUREMENTS

- ALTERNATIVE MAY BE CHAOS

0222(S)-4

TRAINING

- CSC SUPPORTS
  - RECOGNITION OF IMPORTANCE
  - FORMULATION OF NASA CURRICULUM
  - NASA-WIDE TRAINING
  - RECOGNITION OF SCOPE NEEDED

- CONCERNS
  - ADEQUATE RECOGNITION OF COSTS INVOLVED
  - INADEQUATE ATTENTION IN COMPETITIVE ENVIRONMENT
  - ROLE OF NASA CURRICULUM FOR CONTRACTORS

RESEARCH AND DEVELOPMENT

- CSC SUPPORTS

  - NASA-WIDE COORDINATION
  - ENHANCEMENT TO GREATER ADA SCOPE
  - ENVIRONMENT, TOOL DEFINITION
  - METRICS DEFINITION AND USE
  - RESOLUTION OF ADA "PROBLEMS"
  - PILOT PROJECTS

- CONCERNS

  - FOCUS OF TOOL AND PROCESS R&D –
    ATTACK REQUIREMENTS SPECIFICATION ISSUES
  - SYNERGISM WITH OTHER R&D PROGRAMS

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NASA INFRASTRUCTURE

- **CSC SUPPORTS**

  - DEVELOPMENT OF COMMON NASA FRAMEWORK AND STANDARDS
  - NEED FOR AGENCY-LEVEL ORGANIZATION(S) FOR FOCUS AND COORDINATION
  - DEFINITION OF FUNCTIONAL ENVIRONMENT

- **CONCERNS**

  - POTENTIAL FOR OVERLY RIGID STANDARDS
  - TASK FORCES AS POSSIBLE SUBSTITUTE FOR REAL INFRASTRUCTURE
  - POSSIBLE STANDARDIZATION ON SPECIFIC NASA ENVIRONMENT
  - NASA REINVENTING THE WHEEL

0222(S)-7

REUSE

- **CSC SUPPORTS**

  - **REUSE IDENTIFICATION AS KEY TO PRODUCTIVITY INCREASE**
  - **RECOGNITION OF RUDIMENTARY STATE**

- **CONCERNS**

  - **NO SPECIFIC RECOMMENDATIONS TO ADVANCE REUSE**
  - **PROGRAM NEEDED TO DEFINE AND IMPLEMENT REUSE STRATEGY, INFRASTRUCTURE**

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CSC-9

METRICS

- **CSC SUPPORTS**

  - IDENTIFICATION OF METRICS AS A KEY TO PROCESS IMPROVEMENT
  - DEFINITION OF AGENCY-WIDE STANDARD METRICS
  - NEED TO START WITH ESSENTIALS

- **CONCERNS**

  - RELATION TO OTHER METRICS PROGRAMS
  - CONFIDENTIALITY
  - OBJECTIVE MEASUREMENT OF QUALITY, RELIABILITY, ADAPTABILITY, FLEXIBILITY

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0222(S)-9

CSC-10

CONTRACTOR INCENTIVE

- CSC SUPPORTS

  - NEED FOR PROCUREMENTS TO ENCOURAGE
    (REQUIRE) IMPROVED SOFTWARE ENGINEERING
  - EVALUATIONS EMPHASIZING CRITICAL FACTORS

- CONCERNS

  - PROCUREMENT AMBIGUITY
  - TRAINING COST EVALUATION
  - PRODUCTIVITY EXPECTATIONS DURING TRANSITION

- REMEMBER – WINNING BY RESPONDING TO NASA'S
  REQUIREMENTS IS THE KEY INCENTIVE – NASA MUST BE
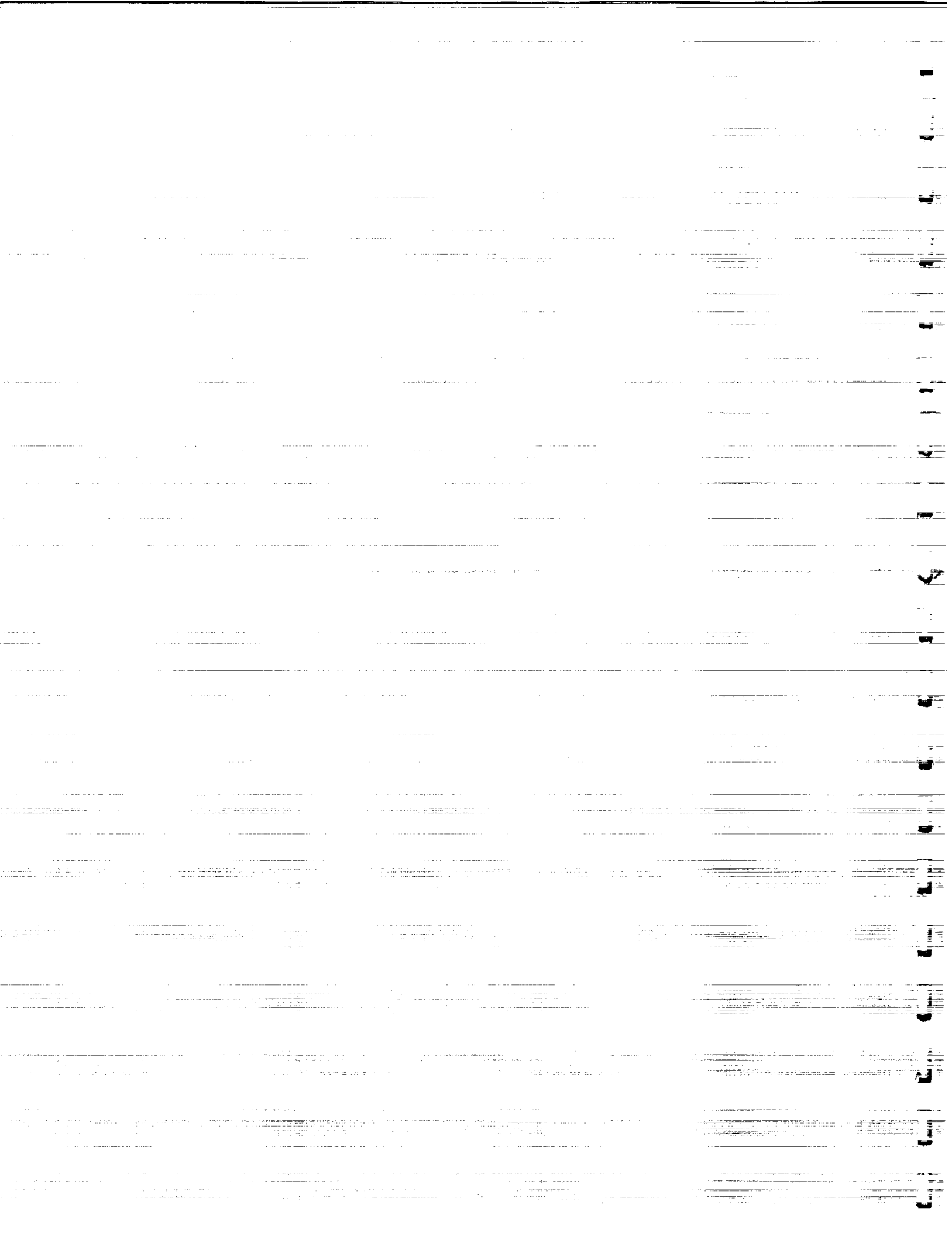 CLEAR

CONCLUDING REMARKS

- **FINE BASELINE FOR DEPARTURE**

- **MANY KEY ISSUES INDENTIFIED**

- **JOINT NASA/CONTRACTOR ACTIVITY ESSENTIAL FOR MAXIMUM RETURN**

- **PROGRAM FORMALIZATION NEEDED**

- **AVOID WHEEL REINVENTION – MANY ISSUES BROADER THAN NASA**

Ada AND SOFTWARE MANAGEMENT

Joe McCabe

McDonnell Douglas Space Systems Company

ADA & SOFTWARE MANAGEMENT

**J. J. McCABE
31 MAY 1989**

**McDonnell Douglas Space Systems Company
Space Station Division**

McDONNELL DOUGLAS EVALUATION TEAM

- **McDonnell Douglas Space Systems Company**

  - Joseph McCabe

  - Robert Dausch

  - Richard Knackstedt

- **McDonnell Douglas Electronics Systems Company**

  - Marvin Carr

  - William Halley

  - Robert Ensey

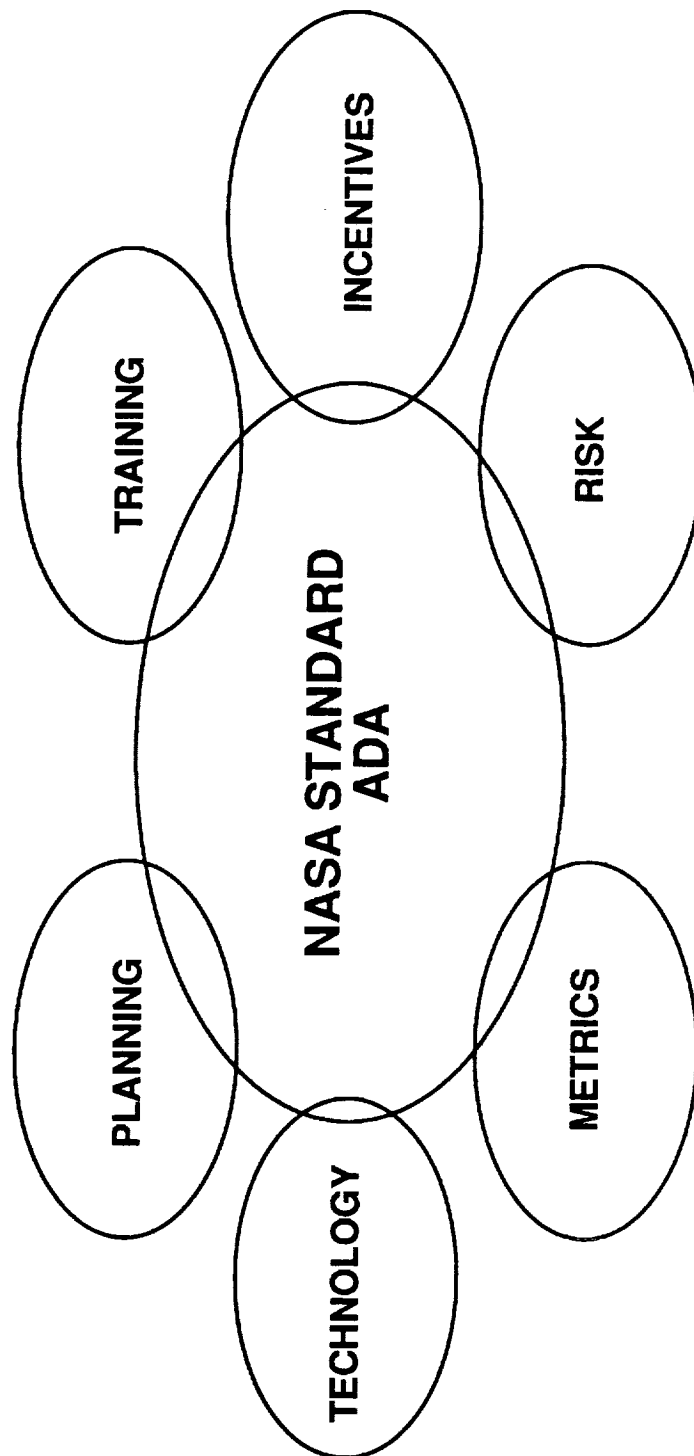# Agenda

- Comments on Recommendations

- Comments on Plan

- Impact on McDonnell Douglas

- Summary

McDonnell Douglas Space Systems Company
Space Station Division

J. J. McCabe
Page 3

RELATIONSHIP OF RECOMMENDATIONS

J. J. McCabe
Page 3

Comments on Recommendations

- Recommendations are basically good

- Plan supports the recommendations generally

- Approach may not be the most cost effective

- Process requires long term commitment, funding and NASA-wide support

- Process needs industry involvement

Issues With Recommendations & Plans

- NASA should use resources outside the agency to achieve the goals and leverage from that outside work

- Creation of a software support environment will only work if it is flexible, responsive to change and is fully supported

- Training must extend beyond NASA and software groups to include systems engineering, product assurance, contracts and finance groups

- Metrics should be collected at large and not be used as a weapon against contractors

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Space Station Division

J. J. McCabe
Page 5

MD-6

Issues With Recommendations & Plans

- Exceptions to use of NASA standard language should not require a complex waiver process but justifications should be recorded in a knowledge base

Impact To McDonnell Douglas

- Common NASA standards & policies that differ from DOD is an added expense

- Creating and supporting a compatible software support environment can add cost and reduce efficiency

- Selection of Ada will cause a lower initial productivity due to the learning curve

- A complex metrics collection task and a risk management plan which is out of prospective with the project will add cost

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Space Station Division

J. J. McCabe
Page 7

SUMMARY

- Everybody benefits from focused effort that relates to real projects

- An integrated NASA/DOD/industry/academia plan is needed to avoid wasteful duplication

- Task must be funded with a commitment from NASA to enforce the results

- System Engineering needs a similar plan

- McDonnell Douglas in general supports the recommendations and 5 year plan

MD-9

TRW COMMENTS ON "Ada AND SOFTWARE MANAGEMENT IN NASA: ASSESSMENT AND RECOMMENDATIONS"

Mike Hollowich
TRW

TRW Comments on

"Ada and Software Management in NASA: Assessment and Recommendations"

Hal Hart
Ada Office Manager
Systems Development Division
TRW Defense Systems Group

31 May 1989

Page 1

TRW-1

Summary

TRW

- The NASA Working Group is to be commended for their recognition of Ada's potential to improve software engineering, their commitment to Ada preparation and insertion, their careful survey and self-examination, and their comprehensive recommendations

- A needed next step, before real planning, is a costs/benefits analysis and prioritization of the recommendations

- A major concern: The "common software support environment" objective (7.4) is so vague that its realization may involve conflicts and may be unaffordable

  - We offer some analysis of options

- NASA has a major opportunity to leverage on (if not join hands with) ongoing DoD initiatives in research, reuse, software metrics, process models, development standards, program office preparation, product and contractor assessment, and policy

  - Resulting commonality benefits NASA's contractors too

Page 2

TRW-2

The Common Software Support Environment Recommendation (7.4/1.4)

7.4 Software Development Environments: NASA should evolve toward a common software support environment.

"To evolve toward a common use of Ada without striving toward a common support environment would be inconsistent with the philosophy of Ada. NASA should not impose a single, fixed hardware and software architecture or a single set of precisely specified software tools on contractors. However, NASA should define a common set of functional capabilities that would become the common environment for NASA software development. NASA should also define standard requirements for deliverables, e.g., language and medium. This policy would not preclude contractors from using their own specialized tools to assist the development process. NASA should also take responsibility for generating the standard set of functional capabilities on common support systems and makinng the resulting environment available for use on contracted software efforts."

Questions About the Common Support Environment Recommendation

- Does it or does it not imply defining a *single, specific technical method* for each lifecycle activity?

- Does it or does it not imply NASA *acquisition of tools* implementing a chosen specific set of technical methods?

- Does it require NASA contractors to use (or deliver products produced by) a specific GFE'd toolset, with a contractor's specific tools optionally used to supplement the *mandatory GFE toolset*, or may contractor's tools (and different methods) be *substituted* for GFE tools?

- Does the recommended "standard requirements for deliverables" mean representations of all artifacts of development processes and their interrelationships (e.g., requirements traced to designs & code & tests, etc.)?

Questions About the Common Support Environment Recommendation (cont.)

TRW

- **Does it imply *portability of tools* -- stand-alone or as interacting suites?**

- **Does it recognize the trade-offs and complex interactions between:**

  - Support for *Reuse?*

  - *Compatibility of technical methods* (and data exchange between tools) chosen for different lifecycle activities?

  - *Compatible, exchangeable representations* of information (and its relationships) between environments?

  - Adaptability to different projects' *process models* (or methods) and assistance or enforcement of each project's?

  - Assistance to tool builders *versus* systems builders?

  - Commercial *supportability* (maintenance) of the support environment?

Page 5

A Prioritization of Environment Objectives?

- Supportability
  - Can't be used on real projects without it
  - May require compromise of other objectives
- Support for Reuse
  - Biggest productivity potential
  - Far-reaching impacts on other objectives & implementation approach
- Information/data (& relationships) commonality or exchangeability
  - including ease of modeling project's information requirements
- Compatible support for advanced requirements & design methods
- Adaptability/enforcement of methods chosen by project management
  - might be higher priority if not so R&D-ish
- Portability of tools
  - low payoff if not fulfilling other objectives

NASA SOFTWARE CONTRACTORS – IMPRESSIONS AND IMPACTS

Jeff Neufeld

GE Aerospace
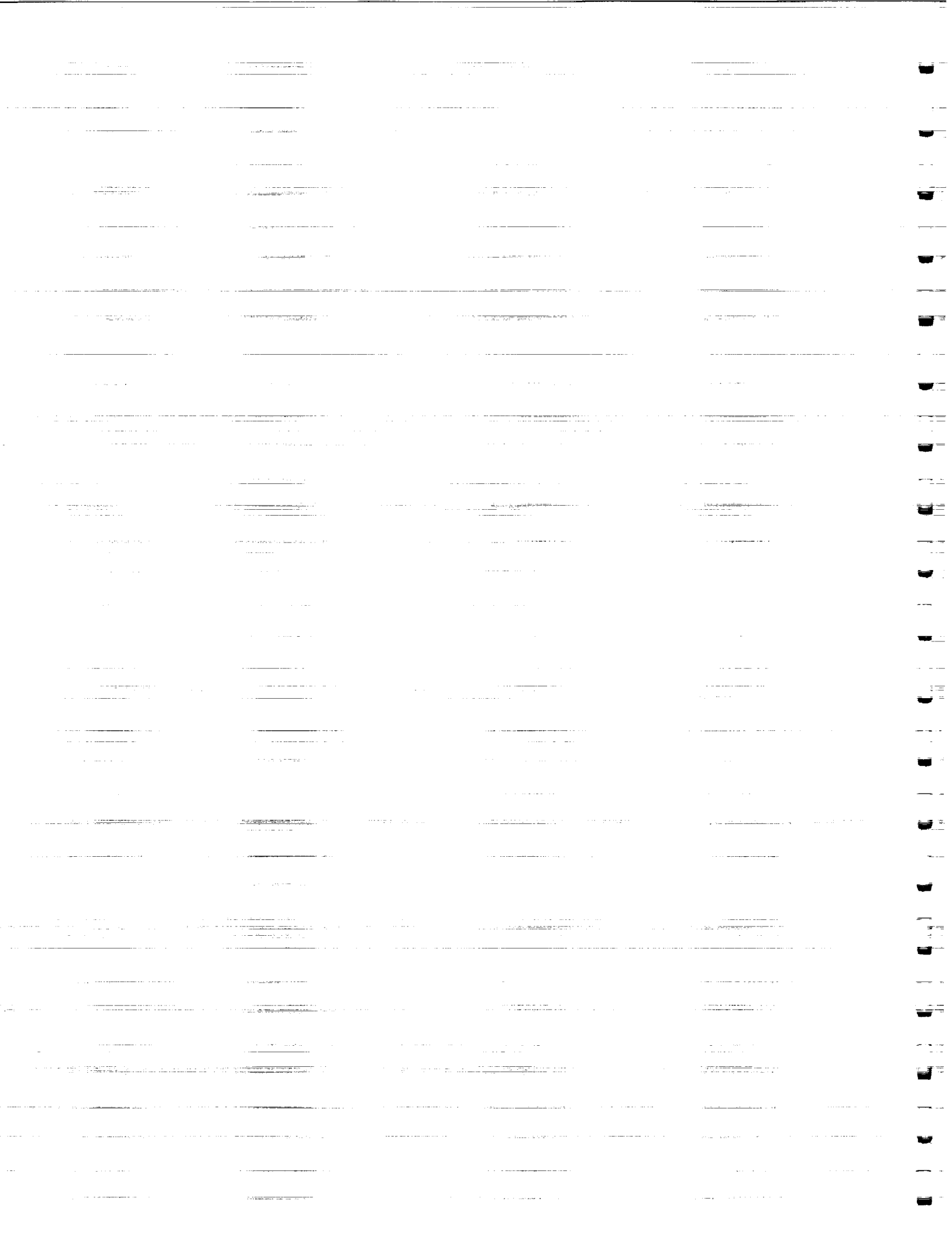
GE Aerospace

ADA AND SOFTWARE MANAGEMENT IN NASA SYMPOSIUM AND FORUM

NASA SOFTWARE CONTRACTORS – IMPRESSIONS AND IMPACTS

MAY 31 – JUNE 1, 1989

J. NEUFELD

SD89-002-JN/5-24-88

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ADA AND SOFTWARE MANAGEMENT IN NASA

- GE AEROSPACE ENDORSEMENTS, CONCERNS, AND SUGGESTIONS ARE PRESENTED

- WE'VE FOCUSED ON KEY NASA OBJECTIVES WHICH MOST STRONGLY IMPACT CONTRACTORS

  - NASA MANAGEMENT INSTRUCTION MANDATING ADA

  - STANDARDS

  - SOFTWARE DEVELOPMENT ENVIRONMENTS

  - CONTRACTOR INCENTIVES

  - THREE-PHASE TRANSITION

  - SOFTWARE MEASUREMENT PROGRAM

SD89-002-JN/5-25-89

GE-2

NASA MANAGEMENT INSTRUCTION MANDATING ADA

- ENDORSEMENT

  - TECHNICAL AND SOFTWARE ENGINEERING ISSUES ASIDE . . . STANDARDIZATION OF LANGUAGES ALONE IS SUFFICIENT RATIONALE FOR A STRONG ENDORSEMENT

    1. QUALITY SOFTWARE ENGINEERING AND CONTINUED IMPROVEMENT REQUIRE INVESTMENT

    2. CUSTOMER BUDGETS DEFINE THE MARKET . . . AND IN A PERIOD OF BUDGET PRESSURE, CONTRACTOR INVESTMENT BECOMES CONSTRAINED BY BUSINESS NECESSITY

    3. AN IMMEDIATE FOCUSED STRATEGY ON THE PART OF NASA WILL RESULT IN THE MOST EFFECTIVE RESPONSE AND INVESTMENT BY INDUSTRY

  - THE MARKET DRIVERS FOR ADA (SPECIFICALLY DoD AND INTERNATIONAL) ARE ALSO GOOD BUSINESS REASONS TO FOCUS ON ADA

  - ALTHOUGH NOT CONCLUSIVE, THE SOFTWARE ENGINEERING ADVANTAGES OF ADA HAVE BEEN SEEN IN SUFFICIENT EVIDENCE TO WARRANT CONFIDENCE

SD89-002-JN/5-30-89

JN-3

NASA MANAGEMENT INSTRUCTION MANDATING ADA
(CONT)

- **CONCERNS**

  - WAIVERS, AS INDICATED IN THE REPORT, WILL BE REQUIRED. . . THE WAIVER PROCESS MUST NOT BE TOO BURDENSOME

- **SUGGESTIONS**

  - ALLOW WAIVERS FOR "OBVIOUS" REASONS TO BE A QUICK, PROGRAM-SPECIFIC CALL

    1. IMMATURE (PERFORMANCE, FEATURES) COMPILER ON THE TARGET HARDWARE

    2. REUSE OF EXISTING NON-ADA CODE (LEGACY OR COMMERCIAL)

    3. SIZE, WEIGHT, POWER CONSTRAINTS OF THE HARDWARE REQUIRE MINIMUM ROM/RAM

SD89-002-JN/5-24-89

STANDARDS

- **ENDORSEMENT**

  – ADOPTION OF STANDARDS FOR SOFTWARE DEVELOPMENT, MANAGEMENT, ACQUISITION, AND ASSURANCE PROVIDE THE SAME BENEFIT AS ADA . . . STANDARDIZATION

    1. INDUSTRY CAN RESPOND WITH FOCUSED INVESTMENT

    2. UTILITY OF THE "NASA CONTRACTOR WORK FORCE" IS INCREASED

  – STRONGLY SUPPORT TAILORING APPROVAL AUTHORITY AT THE NASA PROJECT MANAGER LEVEL

- **CONCERNS**

  – THE REPORT'S OBJECTIVE CITES THE NEED FOR "DEVELOPMENT" OF NASA STANDARDS

    1. DoD–STD–2167X HAS ALREADY BEEN ESTABLISHED AND IS STRONGLY SUPPORTED BY COMMERCIAL TOOLS . . . INDUSTRY ALREADY MAKING SIGNIFICANT INVESTMENTS

  – TAILORING PRIOR TO CONTRACT AWARD CAN COMPLICATE COMPETITIVE COMPETITIVE PRICE COMPARISONS

- **SUGGESTIONS**

  – STAY AS CLOSE TO 2167X AS POSSIBLE . . . TERMINOLOGY, DOCUMENTATION, ETC.

    1. PROVIDE A STANDARD NASA–WIDE TAILORED BASELINE

  – HAVE CONTRACTORS BID TO A PROJECT–MODIFIED BASELINE FOR COMPETITIVE COMPARISON . . . FINAL NASA/CONTRACTOR TAILORING AFTER CONTRACT AWARD

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SOFTWARE DEVELOPMENT ENVIRONMENTS

- ● ENDORSEMENT
  - — ADOPTION STANDARD FOR IN-HOUSE NASA DEVELOPMENT IS TOTALLY APPROPRIATE AS A MECHANISM FOR FOCUSED AND EFFECTIVE USE OF RESOURCES
  - — A FUNCTIONALLY COMMON DEVELOPMENT ENVIRONMENT FOR THE NASA CONTRACTOR COMMUNITY IS DESIRABLE TO:
    1. FACILITATE INTEROPERABILITY OF SOFTWARE PRODUCTS ON LARGE PROGRAMS
    2. BENCHMARK RISK ASSESSMENT OF CONTRACTOR READINESS

- ● CONCERNS
  - — NASA IS "DEVELOPING" AN ENVIRONMENT. . . SO IS THE COMMERCIAL TOOL MARKET
  - — THE SPECIFIC TOOL SETS, PROCESSES, AND METHODS EMPLOYED BY A CONTRACTOR ARE A FACTOR IN COMPETITIVE POSTURE. . . A COMPETITION THAT ULTIMATELY BENEFITS NASA

- ● SUGGESTIONS
  - — FOCUS NASA "STANDARD SOFTWARE DEVELOPMENT ENVIRONMENT" EFFORTS ON TWO AREAS:
    1. DEFINITION OF STANDARD NASA FORMATS FOR ALL SOFTWARE PRODUCTS TO ALLOW INTEROPERABILITY
    2. A DEFINITION OF FUNCTIONAL CAPABILITIES

CONTRACTOR INCENTIVES

- ● **ENDORSEMENT**

  - – REPORT CORRECTLY FOCUSES ON COST BARRIERS OF ADA

    1. COMPANIES MUST BALANCE INCREASED INVESTMENT AGAINST COMPETITIVE POSTURE

    2. HIRING/TRAINING OF ADA SOFTWARE ENGINEERS IS AN ADDITIONAL COST

    3. ESTABLISHING A DEVELOPMENT ENVIRONMENT IS AN ADDITIONAL COST

  - – REPORT ALSO ACKNOWLEDGES BARRIER OF COST/PERFORMANCE RISKS OF NEW TECHNOLOGY

  - – STRONGLY CONCUR THAT FINANCIAL INCENTIVES FOR CONTRACTOR ADOPTION OF ADA AND STATE-OF-THE-ART SOFTWARE ENGINEERING WILL SPEED PAYBACK TO NASA

    1. NASA COST SHARING AND AWARD FEE INCENTIVES WILL MOTIVATE INDUSTRY BOTTOM-LINE MANAGEMENT TO RESPOND MORE RAPIDLY

  - – ACQUISITION CONSIDERATION OF A CONTRACTOR'S ADA AND SOFTWARE ENGINEERING EXPERIENCE WILL PROVIDE A POSITIVE CATALYST FOR CHANGE

    1. MOTIVATION AND IMMEDIATE PAYBACK FOR INDUSTRY COMMITMENT TO ADA TRANSITION

CONTRACTOR INCENTIVES (CONT)

- CONCERNS

  - SIGNIFICANT ISSUES ARE OUTSTANDING ON INCENTIVES FOR REUSE

    1. LIABILITY AND WARRANTY EXPOSURE VERSUS REWARDS FOR REUSE

    2. OBLIGATIONS AND COST FOR TEST

    3. DATA RIGHTS

- SUGGESTIONS

  - APPROACH COST SHARING FOR TRAINING AND ENVIRONMENTS AS AN "INVESTMENT–COMMITMENT"

    1. NASA PROVIDES INVESTMENT IN THE CHOSEN CONTRACTOR(S) WITH THE EXPECTATION OF A RETURN (e.g., INCREASED PRODUCTIVITY, REDUCED ERRORS, ETC.)

    2. CONTRACTORS MAKE COMMITMENTS FROM THEIR BASELINE (ASSUMES AND MOTIVATES A METRICS PROGRAM SIMILAR TO THE RECOMMENDED NASA MEASUREMENT PROGRAM)

    3. NASA AND CONTRACTOR(S) SHARE BENEFITS OF EXCEEDED COMMITMENTS – REDUCED PROGRAM COSTS FOR NASA AND INCREASED INCENTIVE FEES FOR CONTRACTOR(S)

GE-8

SD88–002–JN/5–25–89

CONTRACTOR INCENTIVES (CONT)

- **SUGGESTIONS (CONT)**

  - NASA STANDARD SOFTWARE ENGINEERING AND ADA CURRICULUM AS ADDRESSED IN THE REPORT

    1. REQUIRED FOR NASA AND CONTRACTOR MANAGEMENT PRIOR AND AFTER CONTRACT AWARD

    2. VITAL FOR ADDRESSING COST/PERFORMANCE RISK OF NEW TECHNOLOGY

  - REUSE OF SOFTWARE PROMISES THE EASIEST, SUREST, AND MOST RAPID PAYBACK OF ADA

    1. ESTABLISH NASA LIBRARIES. . . INCENTIVE FEES FOR ITS USE. . . NASA "CERTIFIES" PRODUCT AND ITS USE

    2. INCENTIVE FEE FOR CONTRACTOR DESIGNING AND IMPLEMENTING FOR REUSE. . . POSSIBLY AS A FREQUENCY AND PERCENT OF UNITS REUSED

    3. USE OF NON–NASA AND "OTHER THAN PROJECT" SOFTWARE AWAITS RESOLUTION OF LEGAL BARRIERS

SD88–002–JN/5–25–88

GE-9

THREE-PHASE TRANSITION

- ENDORSEMENT

  - STRONGLY CONCUR WITH A PHASED, INTEGRATED PLAN FOR TRANSITIONING FROM "CODING" SOFTWARE TO "ENGINEERING" SOFTWARE

    1. CENTRAL AND LOCAL PLANNING CLEARLY KEY TO PROPER FOCUS OF NASA RESOURCES WHILE BALANCING NEEDS OF INDIVIDUAL ACTIVITIES

    2. TRAINING OF MANAGEMENT/TECHNICAL PERSONNEL COUPLED WITH "HANDS-ON" IS AN INVESTMENT WE MUST MAKE

- CONCERNS

  - PHASES MAY BE LAGGING THE "ADA INDUSTRY" . . . DELAYING PAYBACK OPPORTUNITY

    1. ADA SEEMS TO BE MATURING FASTER THAN PAST LANGUAGES DUE TO STANDARDIZATION AND MARKET FOCUS

    2. SOME NASA PROGRAMS ALREADY ON CONTRACT WOULD BE DEFINED PHASE 2/3

    3. THE NASA CONTRACTOR BASE IS PERFORMING ON LARGE ADA CONTRACTS NOW

- SUGGESTIONS

  - CONSIDER PARTIAL USE OF ADA SOONER - ON LESS COMPLEX/CRITICAL SOFTWARE

    1. PILOT PROJECTS BECOME SELECTED SOFTWARE ON PRODUCTION PRODUCTS

  - LET CONTRACTOR COMMITMENT AND READINESS DRIVE THE TIMING

SD89-002-JN/5-25-89

JN-10

SOFTWARE MEASUREMENT PROGRAM

- **ENDORSEMENT**

  - STRONGLY CONCUR WITH STANDARD NASA METRICS PROGRAM

    1. "IF YOU CAN'T MEASURE IT . . . YOU CAN'T MANAGE IT . . . AND IT WON'T IMPROVE"

    2. SIMPLE MEASURES (e.g., EFFORT AND ERRORS) MAKE THE BEST NASA–WIDE STANDARDS

  - CONCUR WITH THE USE OF SOFTWARE PROCESS ENGINEERING (SEI) ASSESSMENT METHODS

    1. APPLIED TO ANY SOFTWARE ORGANIZATION AND AS PART OF THE ACQUISITION PROCESS

- **CONCERNS**

  - SOFTWARE MEASUREMENT DOES COST . . . "STANDARD" METRICS TEND TO RAPIDLY BECOME MORE DETAILED AND EXTENSIVE

  - COST OF METRICS BECOMES A BARRIER WHEN BALANCED WITH "COMPETITIVE PRESSURES"

  - SEI ASSESSMENTS ARE NOT MATURE ENOUGH FOR USE AS "TRUTH TELLERS"

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SOFTWARE MEASUREMENT PROGRAM (CONT)

GE Aerospace

- **SUGGESTIONS**

  - CONSIDER A TWO-PRONGED METRICS STANDARD

    1. MANDATED HIGH-LEVEL MEASURES AND A SET OF RECOMMENDED MEASURES

    2. ALLOW PROJECT SELECTION AS APPROPRIATE FOR PROJECT ATTRIBUTES (e.g., SIZE)

  - PROVIDE NASA's FIXED PRICE ADDER FOR MANDATED MEASURES IN THE RFP

  - USE THE SEI ASSESSMENT FOR YES/NO QUALIFICATION ONLY . . . AS A RISK ASSESSMENT GATE

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CONCLUSIONS

- NASA's FOCUS ON SOFTWARE ENGINEERING IMPROVEMENT IS A VITAL STEP TOWARDS ACHIEVING THE PLANNED SYSTEMS OF THE 1990's AND BEYOND

- A FOCUSED STRATEGY AND MANDATE FOR IMPROVED SOFTWARE ENGINEERING/ADA WILL DRIVE RAPID CONTRACTOR RESPONSE

  - STANDARDIZING ON ONE COMMON LANGUAGE DOES NOT SOLVE ALL PROBLEMS . . . BUT GOES A LONG WAY TOWARDS COST EFFECTIVE USE OF RESOURCES

  - LEVERAGING EXISTING INDUSTRY STANDARDS (e.g., 2167A) IS ANOTHER COST-EFFECTIVE OPPORTUNITY

  - FOCUS ON DEFINING "THE WHAT OF STANDARDS" . . . GUARD AGAINST STANDARDS THAT MANDATE "HOW" (e.g., SPECIFIC TOOLS OR METHODS)

- APPROPRIATE COST SHARING AND AWARD INCENTIVES ARE THE BEST MECHANISMS TO FOSTER RAPID PAYBACK FOR SOFTWARE ENGINEERING/ADA TRANSITION

  - CONTRACTORS WILL IMPROVE TO PERFORM . . . MEASURE TO SUBSTANTIATE IMPROVEMENT

  - STRUCTURE "WIN-WIN" INVESTMENT-COMMITMENT ARRANGEMENTS

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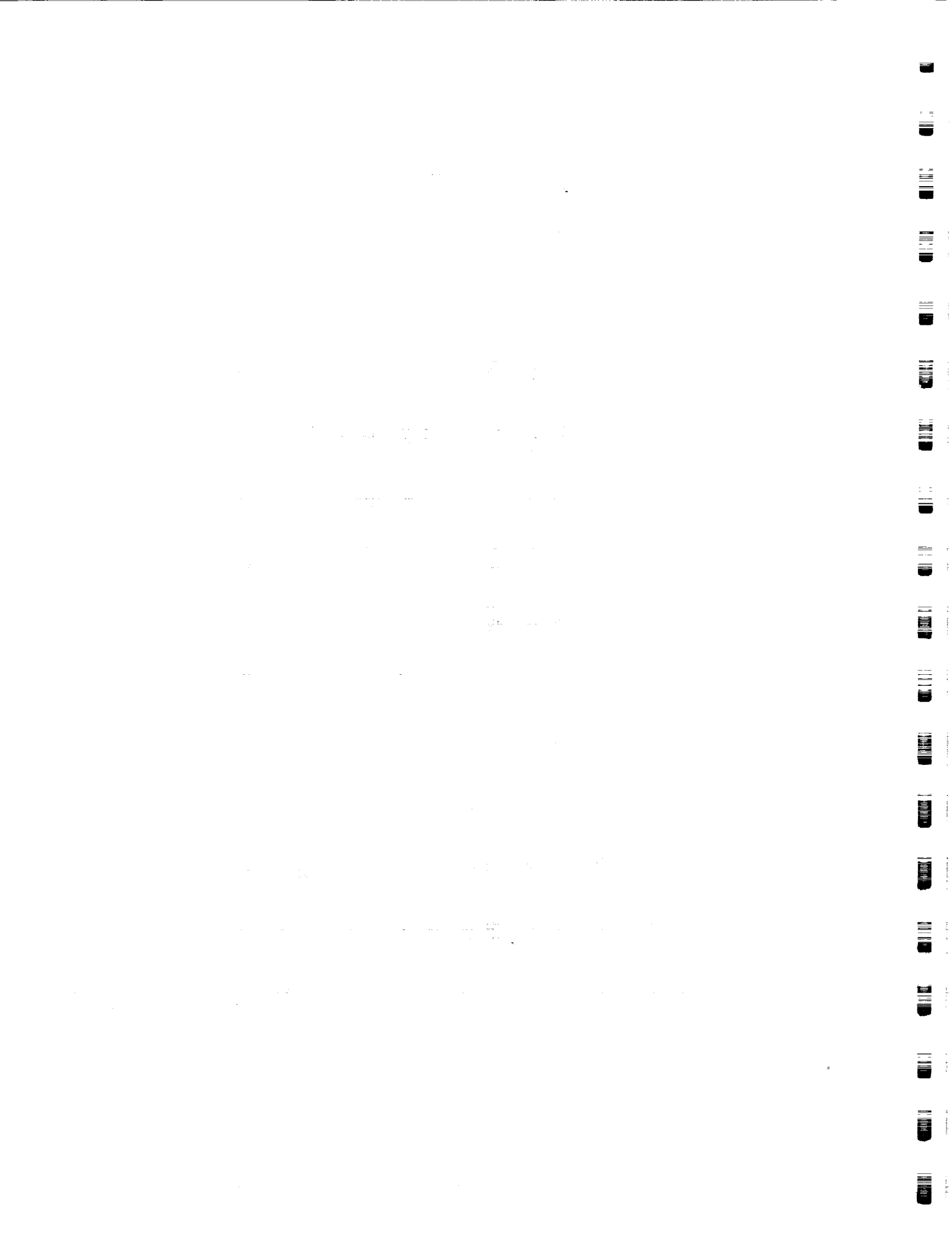
Ada AND SOFTWARE MANAGEMENT IN NASA: AN SSE PERSPECTIVE

Kent Lennington
Lockheed

SSE SYSTEM PROJECT

KENT LENNINGTON
5/31/89

ADA AND SOFTWARE MANAGEMENT IN NASA

AN SSE PERSPECTIVE

ADA AND SOFTWARE MANAGEMENT

OUTLINE

o **ADA, SOFTWARE ENGINEERING AND THE SSE**

o **GENERAL COMMENTS**
- ADA TRANSITION MODEL
- RECOMMENDATIONS

o **SPECIFIC COMMENTS**
- RECOMMENDATIONS 7.2 AND 7.11
- RECOMMENDATION 7.3
- RECOMMENDATION 7.4
- RECOMMENDATION 7.6
- RECOMMENDATION 7.10

2

ADA AND SOFTWARE MANAGEMENT

ADA, SOFTWARE ENGINEERING AND THE SSE

o THE SSFP SOFTWARE SUPPORT ENVIRONMENT REPRESENTS A MAJOR NASA INVESTMENT IN ADA AND SOFTWARE ENGINEERING

- RULES AND TOOLS FOR ADA SOFTWARE PRODUCTION

- AUTOMATED SUPPORT FOR CONTROLLING, DOCUMENTING, AND TRACKING LIFE CYCLE PRODUCTS

- COMMON USER INTERFACE

- TOOL INTEROPERABILITY AND PORTABILITY

3

ADA AND SOFTWARE MANAGEMENT

GENERAL COMMENTS ON THE ADA TRANSITION MODEL

o THE SSE ENDORSES THE TRANSITION MODEL DESCRIBED IN THE REPORT

- MANAGEMENT AND TECHNICAL TRAINING ARE IMPORTANT

- SSFP USE OF THE SSE WILL DEVELOP AN ADA SUPPORT ENVIRONMENT EXPERIENCE BASE

- SSE CAN SERVE AS AN EXAMPLE AGAINST WHICH PROPOSED POLICIES AND STANDARDS CAN BE COMPARED

- SSE WILL SUPPORT THE COLLECTION OF EXTENSIVE METRICS DOCUMENTING
    - THE INFLUENCE OF ADA
    - SOFTWARE ENGINEERING PRACTICES

ADA AND SOFTWARE MANAGEMENT

GENERAL COMMENTS ON RECOMMENDATIONS

o SSE PROJECT GENERALLY SUPPORTS ALL RECOMMENDATIONS

o THE SSE SHOULD SERVE AS A MODEL FOR THE EVOLUTION OF A NASA COMMON SOFTWARE SUPPORT ENVIRONMENT

o THE SSE PROJECT WOULD WELCOME PARTICIPATION IN PROPOSED TASK FORCES
   - SOFTWARE ENGINEERING AND ADA IMPLEMENTATION
   - SOFTWARE PROCESS ENGINEERING

o THE SSE PROJECT WOULD WELCOME PARTICIPATION IN THE DEVELOPMENT AND REVIEW OF NASA SOFTWARE POLICIES AND STANDARDS

L-5

5/31/89

5

ADA AND SOFTWARE MANAGEMENT

RECOMMENDATIONS 7.2 AND 7.11 - CENTRALIZED TASK FORCES

o TWO CENTRALIZED TASK FORCES WHICH WILL OVERSEE AND DIRECT THE IMPLEMENTATION OF MANY OF THE OTHER RECOMMENDATIONS ARE PROPOSED
  - SOFTWARE ENGINEERING AND ADA IMPLEMENTATION TASK FORCE
  - SOFTWARE PROCESS ENGINEERING TASK FORCE

o BOTH TASK FORCES ARE PROPOSED AS CENTRALIZED ORGANIZATIONS WITH 10-15 REPRESENTATIVES
  - NOT CLEAR HOW CONTRACTORS OR NASA PROJECTS PARTICIPATE IN THESE GROUPS

o PERHAPS METHODS TO BROADEN THE INPUT TO THESE GROUPS SHOULD BE CONSIDERED
  - PERIODIC OPEN MEETINGS AND WORKSHOPS
  - WIDELY DISSEMINATED MINUTES
  - SOLICITATIONS OF INPUT ON SPECIFIC ISSUES

6

ADA AND SOFTWARE MANAGEMENT

RECOMMENDATION 7.3 -
POLICIES AND STANDARDS

o THE RECOMMENDATION STATES THAT "NASA SHOULD
   DEVELOP AND ADOPT TAILORABLE STANDARDS FOR
   SOFTWARE DEVELOPMENT, MANAGEMENT, AND ASSURANCE

   - LOCKHEED AND SSE SUPPORT THIS POSITION

o SUCH POLICIES AND STANDARDS SHOULD TAKE INTO
   ACCOUNT DOD 2167A, 2168, AND RELATED DOD STANDARDS

o INDUSTRY REVIEW OF DRAFT STANDARDS, AS PROPOSED IN
   THE RECOMMENDATION, IS HIGHLY DESIRABLE

7

ADA AND SOFTWARE MANAGEMENT

RECOMMENDATION 7.4 -
SOFTWARE DEVELOPMENT ENVIRONMENTS

o THE RECOMMENDATION STATES THAT "NASA SHOULD EVOLVE
   TOWARD A COMMON SOFTWARE SUPPORT ENVIRONMENT."
   - SSE STRONGLY SUPPORTS THIS POSITION
   - IMPLEMENTATION OF THIS RECOMMENDATION IS IN
      QUESTION

o THE RECOMMENDATION SEEMS TO DEFINE AS COMMON
   ENVIRONMENT AS A
   - COMMON SET OF FUNCTIONAL REQUIREMENTS FOR
      DELIVERABLES
   - STANDARD REQUIREMENTS FOR DELIVERABLES
         - LANGUAGE
         - MEDIA

o ALTHOUGH THE RECOMMENDATION IS A GOOD START -
   - IT DOES NOT CONSTITUTE AN ADA SOFTWARE
      SUPPORT ENVIRONMENT
   - IT WILL NOT PROVIDE THE BENEFITS EXPECTED OF AN
      ADA SOFTWARE SUPPORT ENVIRONMENT

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8

ADA AND SOFTWARE MANAGEMENT

RECOMMENDATION 7.6 - TRAINING

o TRAINING IS <u>KEY</u> TO THE SUCCESS OF THE OVERALL PROGRAM

o THOUGHT SHOULD BE GIVEN TO SEPARATE TRAINING FOR MANAGERS AND TRAINING

o THOROUGH TRAINING IS COSTLY BUT ESSENTIAL

o TRAINING SHOULD ALWAYS BE SCHEDULED AND SOMEHOW BE INCENTIVIZED
  - MANY COMPANIES WOULD RATHER HIRE EXPERIENCED ADA PERSONNEL FROM COMPETITORS THAN SPEND THE TIME AND MONEY TO TRAIN

9

ADA AND SOFTWARE MANAGEMENT

RECOMMENDATION 7.10 -
SOFTWARE MEASUREMENT PROGRAM

o   THE RECOMMENDATION STATES THAT "NASA SHOULD ESTABLISH AN AGENCY-WIDE PROGRAM TO COLLECT AND USE SOFTWARE METRICS"

o   THE SSE PROJECT CURRENTLY HAS A REQUIREMENT TO DEFINE AND AUTOMATE THE COLLECTION OF METRICS ASSOCIATED WITH

-   SOFTWARE DEVELOPMENT
-   SOFTWARE REUSE
-   SOFTWARE MANAGEMENT
-   SOFTWARE LIFE-CYCLE

o   THESE METRICS, WHEN FULLY IMPLEMENTED, COULD FORM THE BASIS FOR THE RECOMMENDED MEASUREMENT PROGRAM

5/31/89

10

BOEING RESPONSE TO NASA RECOMMENDATIONS

Weldon Jackson
Boeing Aerospace and Electronics

Systems/ Software Engineering

Ada and Software Management in NASA

Boeing Response To NASA Recommendations

Weldon F. Jackson

31 May 1989

Boeing Aerospace and Electronics

Systems/ Software Engineering	1. Ada Adoption

"NASA should adopt Ada as its standard programming language."

Comment

- Boeing is in committed to complete agreement.

- Boeing is committed to Ada. Over 40 projects are using Ada including SRAM II, SICBM, ATF, Space Station Freedom, LHX, Sea Lance and P3 Update IV.

- Ada ▬▬▬ is being widely used, has a broad range of applications, and provides a foundation for the evolution of software engineering practices.

Boeing Aerospace and Electronics

Systems/
Software
Engineering

2. Software Engineering and Ada Implementation Task Force

"NASA should establish a Software Engineering and Ada Implementation Task Force."

Comment

■ Boeing experienced success with similar approach.

■ Task Force should have reviews with the centers periodically.

■ Should involve DoD, industry and academia.

Boeing Aerospace and Electronics

BAE-3

Systems/
Software
Engineering

3. Policies and Standards

"NASA should develop and adopt tailorable standards for software development, management, and assurance."

Comment

- Boeing is in complete agreement.

- Standards coordinated with DoD would help contractors who have invested in training, internal standards, and environments

- Promotes stability while retaining flexibility.

Boeing Aerospace and Electronics

| Systems/
Software
Engineering | 4. Software Development Environments |

"NASA should evolve toward a common software support environment."

Comment

- **Should support the common software development process.**

- **Suggest that required capabilities and tool interfaces be stressed, not specific methods or tools.**

- **Specifying specific tools may be more expensive.**

- **Approach should be evolutionary.**

Boeing Aerospace and Electronics

| Systems/
Software
Engineering | 5. Transition Planning |

"Each center should develop a plan for evolving to Ada."

Comment

- Boeing agrees with goal.

- Task Force charter should be center approved.

- Center plans should be adapted from Task Force generated policies and standards.

- DoD, industry and academia involvement should be promoted.

Boeing Aerospace and Electronics

Systems/ Software Engineering

6. Training

"...should ensure the development and implementation of an agency-wide core curriculum ... Each center should adapt the core curriculum to its specific needs."

Comment

■ Boeing is in complete agreement.

■ Should build curriculum around basics.

■ Emphasis should be based on NASA's primary role of acquisition management.

■ Training should be available to contractors.

Boeing Aerospace and Electronics

**Systems/
Software
Engineering**

7. Risk Management

"For any "critical " project, management

should be required to develop and

implement a written risk management plan."

Comment

■ Boeing agrees.

■ Policies and standards should
inherently control and reduce risk.

■ With policies and standards in place
risk management can be focused on
project specific areas.

Boeing Aerospace and Electronics

**Systems/
Software
Engineering**

8. Contractor Incentives

"NASA should establish an Ada incentive

program for its software contractors."

Comment

- Contractors should adhere to the NASA mandate to use Ada without requiring special consideration.

- Emphasis should be placed on Contractor's ability to solve the system/application problem not the toolset available.

- Contractors should be rewarded for creating and using reusable code.

Boeing Aerospace and Electronics

Systems/ Software Engineering

9. Coordination of Research and Development

"The Office of Aeronautics and Space Technology (Code R) should plan and coordinate agency-wide software research and development, more of which should support Ada."

Comment

- Many Ada specific efforts are already on-going within DoD, industry, and academia.

- Research should address Ada in the context of NASA applications.

- Coordination should be extended beyond NASA.

Boeing Aerospace and Electronics

10. Software Measurement Program

Systems/ Software Engineering

"NASA should establish an agency-wide program to collect and use software metrics."

Comment

- Boeing agrees. There is a universal need to collect metrics.

- Metrics should be collected for both technical performance measures and contract/cost/schedule performance measures.

- Based on our experience much effort and coordination is required to establish a measurement program.

- Should coordinate with DoD, industry and academia. **Boeing Aerospace and Electronics**

Systems/ Software Engineering	**11. Software Process Engineering Task Force**

"NASA should establish a Software

Process Engineering Task Force to support

the evaluation and improvement of the

agency's software acquisition and in-house

development processes."

Comment

- Boeing agrees with idea of process
  improvement teams.

- Need instruction and training.

- Boeing supports SEI assessment
  method.

Boeing Aerospace and Electronics

12

Conclusions

Systems/ Software Engineering	

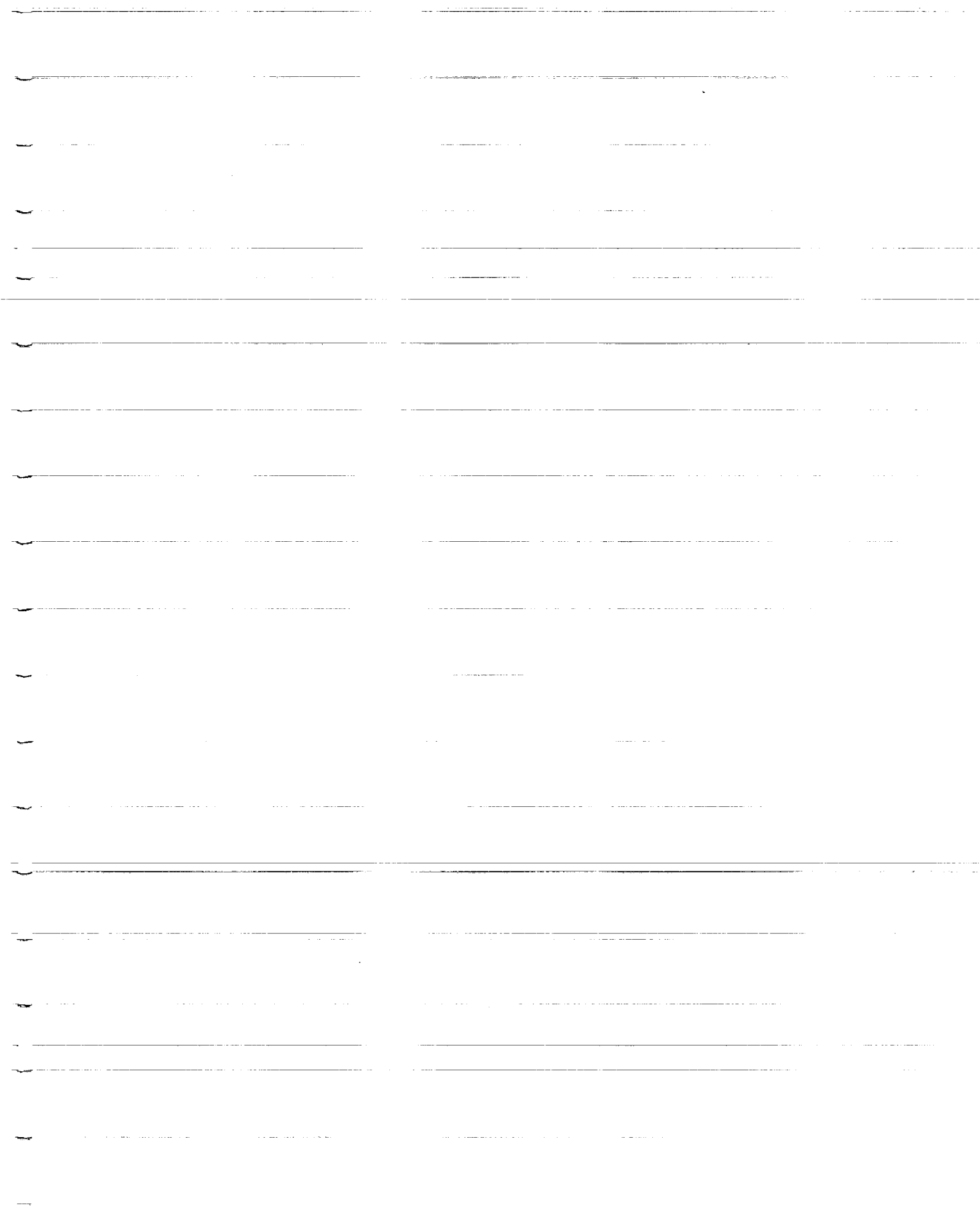- **NASA recommendations have minimal impact on Boeing**

- **Boeing has implemented internal embedded software standards and a software support environment which meet DoD requirements.**

Boeing Aerospace and Electronics

13

List of Attendees

The following pages present a list of those who attended the Ada and Software Management in NASA Symposium and Forum at GSFC on May 31-June 1, 1989.

41

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ACCARDI, MIKE	ELECTRONIC DATA SYSTEMS
ACTON, THOM	UNISYS CORP.
ADAMS, NEIL	BENDIX FIELD ENGINEERING CORP.
AGRESTI, BILL W	MITRE CORP.
AICHELE, DAVID	NASA/MSFC
ANDERS, ANTHONY A	FORD AEROSPACE CORP.
ANDREOTTA, DONALD J	NASA/HEADQUARTERS
ARMSTRONG, TOM	NASA/HEADQUARTERS
AUTY, DAVID	SOFTECH
AZUMA, KENNETH	FORD AEROSPACE CORP.
BARDIN, BRYCE	HUGHES AIRCRAFT CO.
BARKSDALE, JOE	NASA/GSFC
BASILI, VIC	UNIVERSITY OF MARYLAND
BESWICK, CHARLIE	NASA/JPL
BISHOP, JOE	NASA/HEADQUARTERS
BLAND, SKIP A .	UNISYS CORP.
BOBZIEN, GALE	GRUMMAN
BOOTH, ERIC	COMPUTER SCIENCES CORP.
BRADFORD, W. CLIFF	SMITH ADVANCED TECHNOLOGY, INC.
BRADLEY, STEPHEN	MMS SYSTEMS
BREDESON, MIMI	STScI
BREDESON, RICHARD W	OMITRON, INC.
BROOKS, OSCAR	NASA/KSC
BUNKER, BOB	NASA/JPL
BURGIN, GEORGE	PLANNING RESEARCH CORP.
BURLEY, RICK	NASA/GSFC
BURTON, BRUCE	INTERMETRICS
BUSH, MARILYN	NASA/JPL
CAMPBELL, RICHARD T	MARTIN MARIETTA
CARMODY, CORA	PLANNING RESEARCH CORP.
CARR, MARVIN	MCDONNELL DOUGLAS
CARRO, TONY	NASA/HEADQUARTERS
CARROLL, ROSSYE	COMPUTER SCIENCES CORP.
CASSELL, SEAN	FORD AEROSPACE CORP.
CHEVERS, EDWARD S	NASA/JSC
CHU, RICHARD	FORD AEROSPACE CORP.
COLAIZZI, DONALD	COMPUTER SCIENCES CORP.
CORNELL, CATHY	UNISYS CORP.
CORTEZ, ROMO V	NASA/HEADQUARTERS
CREEGAN, JIM	FORD AEROSPACE CORP.
DAKU, WALTER	VITRO CORP.
DALTON, JOHN T	NASA/GSFC
DAVIS, TED	BOEING
DEMAIO, LOUIS	NASA/GSFC
DIKEL, DAVID	FOCUSED ADA RESEARCH
DOYLE, JOHN	BENDIX FIELD ENGINEERING CORP.
DUFFY, BILL	NASA/GSFC
EARL, MICHAEL	INTERMETRICS
EMERSON, CURTIS	NASA/GSFC
EMMART, CONNIE R	COMPUTER SCIENCES CORP.

5443

ESKER, LINDA	COMPUTER SCIENCES CORP.
EVANCO, WILLIAM	MITRE CORP.
FAIRLEY, DICK	GEORGE MASON UNIVERSITY
FANG, AI	NASA/HEADQUARTERS
FEAGAN, J. LARRY	NASA/LeRC
FERNANDEZ, AL	COMPUTER SCIENCES CORP.
FISHER, JACKIE	NASA/JSC
FLEMING, JUDY	IBM
FOX, EILEEN	IDE
FRY, KEN	MITRE CORP.
GARDNER, MIKE	COMPUTER SCIENCES CORP.
GARMAN, JACK R	NASA/JSC
GARVIS, MICHAEL	LOCKHEED
GERMANA, GUY	ST SYSTEMS CORP.
GERNERT, EARL	NASA/GSFC
GERSTNER, DIETWALD A	NASA/HEADQUARTERS
GIESER, JIM	VITRO CORP.
GIRAGOSIAN, PAUL	MITRE CORP.
GODFREY, SALLY	NASA/GSFC
GOEDDEKE, VINCENT	BOEING
GREEN, DAVID	COMPUTER SCIENCES CORP.
GRIFFITH, BYRON	NASA/KSC
GRIMALDI, STEVE	BOOZ-ALLEN & HAMILTON
GUPTA, LAKSHIM	FORD AEROSPACE CORP.
HABBOK, ALI	FORD AEROSPACE CORP.
HAHN, DEBBIE	NASA/KSC
HAIN, GERTRUD	SHBAS
HAIN, KLAUS	SHBAS
HALL, GARDINER	NASA/GSFC
HARRIS, BERNARD	NASA/GSFC
HEFFERNAN, MICK	COMPUTER SCIENCES CORP.
HELLER, GERRY	COMPUTER SCIENCES CORP.
HILL, BILL	COMPUTER SCIENCES CORP.
HILL, KEN	NASA/GSFC
HODGES, DEIDRA	MARTIN MARIETTA
HOLLOWICH, M	TRW
HOLOUBEK, DAN	LMSC
HOOD, CARROLL	SAIC
HOOTEN, MONICA	FORD AEROSPACE CORP.
HORNSTEIN, RHODA S	NASA/HEADQUARTERS
HUGHES, MICHAEL	NASA/JPL
HULL, LARRY	NASA/GSFC
HYATT, LARRY	NASA/GSFC
INGALE, S M	COMPUTER SCIENCES CORP.
JACKSON, WELDON	BOEING
JELETIC, JIM	NASA/GSFC
KEENE, WALLACE O	NASA/HEADQUARTERS
KELLY, LISA	NASA/GSFC
KESTER, RUSH	GTE GOVERNMENT SYSTEMS
KLITSCH, JERRY	COMPUTER SCIENCES CORP.
KOPP, AL	TELESOFT
KRELL, BRUCE E	HUGHES AIRCRAFT CO.
KUDLINSKI, ROBERT A	NASA/LaRC

5443

LABAUGH, ROBERT	MARTIN MARIETTA
LAL, NAND	NASA/GSFC
LAME, DAVID	NASA/JPL
LANDIS, LINDA	COMPUTER SCIENCES CORP.
LAVALLEE, DAVID	FORD AEROSPACE CORP.
LENNINGTON, KENT	LOCKHEED MISSILE & SPACE SYSTEMS
LEVINSON, LAURIE	NASA/LeRC
LEWIS, TINA	GTE
LITTMANN, DAVE	NASA/GSFC
LIU, JEAN C	COMPUTER SCIENCES CORP.
LIU, KUEN-SAN	COMPUTER SCIENCES CORP.
LUCIER, ERNIE	NASA/HEADQUARTERS
LUCZAK, RAYMOND W	COMPUTER SCIENCES CORP.
LeGRAND, SUE	PLANNING RESEARCH CORP.
MATHIASEN, CANDY	UNISYS CORP.
MCCABE, JOE	MCDONNELL DOUGLAS
MCCLURE, MARTY	BENDIX FIELD ENGINEERING CORP.
MCCOMAS, DAVID	NASA/GSFC
MCCUTCHEON, BOB	COMPUTER SCIENCES CORP.
MCGARRY, FRANK	NASA/GSFC
MCMAHON, SUSAN K	NASA/HEADQUARTERS
MOLARI, RUSSELL E	STERLING FEDERAL SYSTEMS, INC.
MONAGHAN, BRYAN	SOFTECH
MONTEGOMERY, HELEN	INTERMETRICS
MOORE, BYRON B	DEFENSE COMMUNICATIONS AGENCY
MOORE, JR., JOHN T	VITRO CORP.
MUNGLE, JERRY A	TRW
MUNKEBY, STEVE H	MARTIN MARIETTA
MURPHY, ROBERT	NASA/GSFC
NEUFELD, JEFFREY	GENERAL ELECTRIC CORP.
NICHOLS, DAVID	NASA/JPL
NOLAN, SANDRA K	PLANNING RESEARCH CORP.
O'BRIEN, DAVID	CONCURRENT COMPUTER
O'DONNELL, HUGH	NASA/GSFC
O'NEIL, BOB	NASA/HEADQUARTERS
ORTIZ, JOSE A	NASA/HEADQUARTERS
PAGE, GERALD	COMPUTER SCIENCES CORP.
PAJERSKI, ROSE	NASA/GSFC
PASCIUTO, MIKE	NASA/HEADQUARTERS
PEARSON, BOYD	NASA/GSFC
PHILLIPS, ROBERT	GTE
PLETT, MICHAEL E	COMPUTER SCIENCES CORP.
POTTER, MARSHALL R	DEPARTMENT OF THE NAVY
POTTER, WILLIAM	NASA/GSFC
PROVENZA, CLINT	BOOZ-ALLEN & HAMILTON
QUANN, EILEEN S	FASTRAK TRAINING, INC.
RADOSEVICH, JIM	NASA/HEADQUARTERS
RAINES, GARY	NASA/JSC
RANADE, PRAKASH V	COMPUTER SCIENCES CORP.
REED, CATHY	COMPUTER SCIENCES CORP.
RIORDAN, RALPH M	NASA/GSFC
RITTER, SHEILA J	NASA/GSFC
ROE, BOB L	BOEING
ROY, DAN	FORD AEROSPACE CORP.

5443

SABATINO, RICK	OMITRON, INC.
SATRAN, DALE	NASA/HEADQUARTERS
SAUBLE, GEORGE	OMITRON, INC.
SCANLON, PAUL	DELEX SYSTEMS, INC.
SCHMIDT, SANDY	BOOZ-ALLEN & HAMILTON
SCHUBERT, KATHLEEN E	NASA/LeRC
SCHUETZLE, JIM	FORD AEROSPACE CORP.
SCHULER, MARY P	NASA/LaRC
SCOTT, BARBARA	NASA/GSFC
SEIDEWITZ, ED	NASA/GSFC
SHANK, DWIGHT	COMPUTER SCIENCES CORP.
SHI, LEON	COMPUTER SCIENCES CORP.
SHOAN, WENDY	NASA/GSFC
SMITH, PAUL H	NASA/HEADQUARTERS
SOVA, DON	NASA/HEADQUARTERS
SPENCE, C. BAILEY	COMPUTER SCIENCES CORP.
SPIEGEL, MITCH	GTE
STARK, MICHAEL	NASA/GSFC
STOKES, ED	COMPUTER SCIENCES CORP.
STONESIFER, G. RICHARD	NASA/GSFC
STRAUB, PABLO	UNIVERSITY OF MARYLAND
STUART, A D	DEPARTMENT OF THE NAVY
TARZIER, TIM	DAEDALEAN, INC.
TASAKI, KEIJI	NASA/GSFC
TAUSWORTHE, BOB	NASA/JPL
TAYLOR, DICK	COMPUTER SCIENCES CORP.
THACKREY, KENT	PLANNING ANALYSIS CORP.
THOMPSON, SCOTT	NASA/HEADQUARTERS
THORNTON, THOMAS	NASA/JPL
TIERNEY, PAUL	GENERAL ELECTRIC CORP.
TIGHE, MICHAEL	INTERMETRICS
TYSON, MELSUN	NASA/HEADQUARTERS
VALE, PAUL	STORAGE TEK
VENKATARAMAN, RAVI	ST SYSTEMS CORP., STX
VOIGT, DAVID	BENDIX FIELD ENGINEERING CORP.
VOLANSKY, SAUL A	HUGHES AIRCRAFT CO.
WALIGORA, SHARON R	COMPUTER SCIENCES CORP.
WALKER, CLAY	COMPUTER SCIENCES CORP.
WALKER, GARY	NASA/JPL
WALL, RAY J	NASA/JPL
WEISMAN, DAVID	UNISYS CORP.
WELCH, NOREEN	COMPUTER SCIENCES CORP.
WESTON, WILLIAM	NASA/GSFC
WILSON, RUSSELL	BOEING
WILSON, WILLIAM	QUONG & ASSOCIATES
WOLVERTON, RAY	HUGHES AIRCRAFT CO.
WOOD, DICK	COMPUTER SCIENCES CORP.
WRIGHT, PATRICIA D	NASA/HEADQUARTERS
WROTNIAK, J A	ST SYSTEMS CORP., STX
ZAHN, MARYANNE P	NASA/GSFC
ZELKOWITZ, MARV	UNIVERSITY OF MARYLAND
ZLAMAN, DENNIS	TELESOFT
ZWIERKO, RICHARD	NASA/HEADQUARTERS

5443